

Theme-D Standard Library Reference

Tommi Höynälänmaa

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Chapter 1

Introduction

Here is an overview for the modules in the Theme-D standard library:

- Module `core` includes basic functionality of the Theme-D environment and it should generally be always included by the user source code.
- Module `core-forms` defines some basic control structures as macros.
- Module `bitwise-arithmetic` implements basic bit operations.
- Module `promise` implements promises (delayed evaluation).
- Module `stream` implements streams.
- Module `iterator` implements purely functional iterators.
- Module `nonpure-iterator` implements nonpure iterators analogous to the pure ones.
- Module `object-string-output` implements readable string forms of the Theme-D objects.
- Module `text-file-io` defines primitive classes for input and output ports and basic operations with them.
- Module `console-io` implements console input and output.
- Module `system` implements some OS level functionality.
- Module `rational` implements rational numbers.
- Module `complex` implements complex numbers.
- Module `real-math` implements operations between real and rational values and real scientific functions. Basic numerical operations are defined in `core`.
- Module `math` implements the numerical tower and generic scientific functions.

- Module `extra-math` implements wrapper procedures for many standard C mathematical functions. Some methods using the wrappers are implemented, too.
- Module `posix-math` implements wrapper procedures for some POSIX C mathematical functions not present in the C standard. Some methods using the wrappers are implemented, too.
- Module `matrix` implements matrices.
- Module `dynamic-list` implements dynamically type checked lists.
- Module `singleton` implements singletons.
- Module `hash-table` implements hash tables.
- Module `statprof` provides an interface to the guile `statprof` profiler.

When we document procedures and methods we use the notation

`proc-name: (arg-type-1 ... arg-type-n) → result-type`

to indicate that method `method-name` takes arguments of types `arg-type-i` and returns a value of type `result-type`.

When we document methods we use the notation

`method-name: (arg-type-1 ... arg-type-n) → result-type = procedure`

that the method is additionally equal to the procedure `procedure`.

The notation

`method-name: (arg-type-1 ... arg-type-n) → result-type abstract`

means that the method only raises an exception and its purpose is to help in the static dispatch of the result type. We write “pure” in a procedure definition to indicate that the procedure is pure.

Chapter 2

Numerical Tower

The Theme-D Standard Library implements a numerical tower similar to Scheme. Easiest way to import it is to import module (`standard-library math`). Numerical types `<integer>` and `<real>` are built in the Theme-D language and types `<rational>` and `<complex>` are implemented by the standard library.

We say that a rational number is in the *simplified form* if its denominator is positive and the greatest common divisor between the numerator and the denominator is 1. Additionally we require that if the numerator is 0 the denominator is 1.

Terms NaN, inf, and -inf mean the exceptional floating point values (not a number, positive infinity, and negative infinity) defined by the IEEE 754 standard. If your system does not support these the behaviour of the procedures in case they are specified to return an exceptional value is undefined.

Numbers belonging to classes `<integer>` and `<rational>` are called *exact* and numbers belonging to classes `<real>` and `<complex>` *inexact*. The terms *exact 0* and *exact 1* mean the integer and rational values 0 and 1.

When the results of the real math functions in module `real-math` are complex or not defined these procedures usually return an exceptional value. When the optimized real functions are used (this is on by default) the complex value is not actually computed but the exceptional values are returned directly.

Chapter 3

Module (standard-library core)

3.1 Control Structures

3.1.1 Data Types

Data type name: <scheme-condition>

Type: <class>

Description: The data type of Scheme exceptions

3.1.2 Simple Procedures

raise

Syntax:

```
(raise exception-object)
```

Arguments:

Name: **exception-object**

Type: <object>

Description: The exception object to be raised

No result value.

Purity of the procedure: pure

Procedure **raise** raises an exception. Exceptions can be caught with **guard** forms, see section 4.1. The semantics of **guard** and **raise** are similar to their

semantics in Scheme.

exit

Syntax:

```
(exit exit-code)
```

Arguments:

Name: `exit-code`

Type: `<integer>`

Description: The exit code passed to the operating system

No result value.

Purity of the procedure: nonpure

Procedure `exit` terminates a program. The exit code given as an argument is passed to the operating system.

3.2 Command Line

3.2.1 Simple Procedures

command-line-arguments

Syntax:

```
(command-line-arguments)
```

No arguments.

Result value: List of command line arguments

Result type: `(:uniform-list <string>)`

Purity of the procedure: pure

3.3 Equality Predicates

3.3.1 Simple Procedures

=

Procedure = is an alias to procedure equal?.

boolean=?

Syntax:

```
(boolean=? object1 object2)
```

Arguments:

Name: `object1`
Type: `<boolean>`
Description: A boolean value to be compared

Name: `object2`
Type: `<boolean>`
Description: A boolean value to be compared

Result value: #t iff `object1` is equal to `object2`

Result type: `<boolean>`

Purity of the procedure: pure

character=?

Syntax:

```
(character=? object1 object2)
```

Arguments:

Name: `object1`
Type: `<character>`
Description: A character to be compared

Name: `object2`

Type: `<character>`

Description: A character to be compared

Result value: `#t` iff `object1` is equal to `object2`

Result type: `<boolean>`

Purity of the procedure: pure

`integer=?`

Syntax:

`(integer=? object1 object2)`

Arguments:

Name: `object1`

Type: `<integer>`

Description: An integer value to be compared

Name: `object2`

Type: `<integer>`

Description: An integer value to be compared

Result value: `#t` iff `object1` is equal to `object2`

Result type: `<boolean>`

Purity of the procedure: pure

`integer-real=?`

Syntax:

`(integer-real=? object1 object2)`

Arguments:

Name: `object1`

Type: `<integer>`

Description: An integer value to be compared

Name: `object2`

Type: `<real>`

Description: A real value to be compared

Result value: #t iff object1 is equal to object2

Result type: <boolean>

Purity of the procedure: pure

real=?

Syntax:

(real=? object1 object2)

Arguments:

Name: object1

Type: <real>

Description: A real value to be compared

Name: object2

Type: <real>

Description: A real value to be compared

Result value: #t iff object1 is equal to object2

Result type: <boolean>

Purity of the procedure: pure

real-integer=?

Syntax:

(real-integer=? object1 object2)

Arguments:

Name: object1

Type: <real>

Description: A real value to be compared

Name: object2

Type: <integer>

Description: An integer value to be compared

Result value: #t iff object1 is equal to object2

Result type: <boolean>

Purity of the procedure: pure

string=?

Syntax:

```
(string=? object1 object2)
```

Arguments:

Name: object1

Type: <string>

Description: A string to be compared

Name: object2

Type: <string>

Description: A string to be compared

Result value: #t iff object1 is equal to object2

Result type: <boolean>

Purity of the procedure: pure

This procedure compares the contents of the argument strings.

symbol=?

Syntax:

```
(symbol=? object1 object2)
```

Arguments:

Name: object1

Type: <symbol>

Description: A symbol to be compared

Name: object2

Type: <symbol>

Description: A symbol to be compared

Result value: #t iff object1 is equal to object2

Result type: <boolean>

Purity of the procedure: pure

3.4 Class Membership Predicates

3.4.1 Data Types

Data type name: <type-predicate>

Type: :procedure

Description: The data type for type membership predicates

3.4.2 Simple Procedures

boolean?

Syntax:

(boolean? object)

Arguments:

Name: object

Type: <object>

Description: An object to be tested

Result value: #t iff object is an instance of <boolean>

Result type: <boolean>

Purity of the procedure: pure

character?

Syntax:

(character? object)

Arguments:

Name: `object`
Type: `<object>`
Description: An object to be tested

Result value: `#t` iff `object` is an instance of `<character>`
Result type: `<boolean>`

Purity of the procedure: pure

`eof?`

Syntax:

`(eof? obj)`

Arguments:

Name: `obj`
Type: `<object>`
Description: An arbitrary object

Result value: `#t` iff `obj` is the eof object
Result type: `<boolean>`

Purity of the procedure: pure

`integer?`

Syntax:

`(integer? object)`

Arguments:

Name: `object`
Type: `<object>`
Description: An object to be tested

Result value: `#t` iff `object` is an instance of `<integer>`
Result type: `<boolean>`

Purity of the procedure: pure

null?*Syntax:*`(null? object)`*Arguments:*

Name: `object`
Type: `<object>`
Description: An object to test

Result value: `#t` iff `object` is null*Result type:* `<boolean>`*Purity of the procedure:* pure**not-null?***Syntax:*`(not-null? object)`*Arguments:*

Name: `object`
Type: `<object>`
Description: An object to test

Result value: `#t` iff `object` is not null*Result type:* `<boolean>`*Purity of the procedure:* pure**pair?***Syntax:*`(pair? object)`*Arguments:*

Name: `object`

Type: <object>
Description: An object to be tested

Result value: #t iff `object` is an instance of <pair>
Result type: <boolean>

Purity of the procedure: pure

This procedure returns #t for any pair.

real?

Syntax:

(real? object)

Arguments:

Name: `object`
Type: <object>
Description: An object to be tested

Result value: #t iff `object` is an instance of <real>
Result type: <boolean>

Purity of the procedure: pure

string?

Syntax:

(string? object)

Arguments:

Name: `object`
Type: <object>
Description: An object to be tested

Result value: #t iff `object` is an instance of <string>
Result type: <boolean>

Purity of the procedure: pure

symbol?

Syntax:

(symbol? object)

Arguments:

Name: object
 Type: <object>
 Description: An object to be tested

Result value: #t iff object is an instance of <symbol>

Result type: <boolean>

Purity of the procedure: pure

3.5 Lists, Tuples, and Pairs

3.5.1 Data Types

Data type name: :a-list

Type: <param-logical-type>

Number of type parameters: 2

Description: An association list

Data type name: :nonempty-a-list

Type: <param-logical-type>

Number of type parameters: 2

Description: An association list containing at least one element

Data type name: :maybe

Type: <param-logical-type>

Number of type parameters: 1

Description: A value that is either null or an instance of the component type

Data type name: :nonempty-uniform-list

Type: <param-logical-type>

Number of type parameters: 1

Description: A uniform list with at least one element

Data type name: <list>

Type: :union

Description: A list consisting of any objects

Data type name: <nonempty-list>

Type: `:pair`

Description: A nonempty list consisting of any objects

Data type name: `<pair>`

Type: `:pair`

Description: A pair consisting of any objects

3.5.2 Simple Procedures

length

Syntax:

```
(length lst)
```

Arguments:

Name: `lst`

Type: `(:uniform-list <object>)`

Description: A list

Result value: Number of elements in the list

Result type: `<integer>`

Purity of the procedure: pure

3.5.3 Parametrized Procedures

car

Syntax:

```
(car pair)
```

Type parameters: `%type1, %type2`

Arguments:

Name: `pair`

Type: `(:pair %type1 %type2)`

Description: A pair

Result value: The first element of the pair

Result type: %type1

Purity of the procedure: pure

cdr

Syntax:

```
(cdr pair)
```

Type parameters: %type1, %type2

Arguments:

Name: pair

Type: (:pair %type1 %type2)

Description: A pair

Result value: The second element of the pair

Result type: %type2

Purity of the procedure: pure

gen-car

Syntax:

```
(gen-car pair)
```

Type parameters: %type1, %type2

Arguments:

Name: pair

Type: (:union (:pair %type1 %type2) <null>)

Description: A pair

Result value: The first element of the pair

Result type: %type1

Purity of the procedure: pure

If the argument is `null` an exception is raised.

gen-cdr

Syntax:

```
(gen-cdr pair)
```

Type parameters: %type1, %type2

Arguments:

```
Name: pair  
Type: (:union (:pair %type1 %type2) <null>)  
Description: A pair
```

Result value: The second element of the pair

Result type: %type2

Purity of the procedure: pure

If the argument is `null` an exception is raised.

cons

Syntax:

```
(cons first second)
```

Type parameters: %type1, %type2

Arguments:

```
Name: first  
Type: %type1  
Description: The first object of the new pair
```

```
Name: second  
Type: %type2  
Description: The second object of the new pair
```

Result value: A pair with values `first` and `second`

Result type: (:pair %type1 %type2)

Purity of the procedure: pure

list

Syntax:

```
(list item-1 ... item-n)
```

Type parameters: %arglist

Arguments:

Name: item-k
Type: t_k
Description: A list item

Result value: A list constructed from the arguments

Result type: %arglist

Purity of the procedure: pure

Metavariable t_k is the type of item-k for each k . Type variable %arglist is equivalent to (:tuple $t_1 \dots t_n$).

drop

Syntax:

```
(drop lst count)
```

Type parameters: %type

Arguments:

Name: lst
Type: (:uniform-list %type)
Description: A list

Name: count
Type: <integer>
Description: Number of elements to be dropped

Result value: A list constructed by dropping away the first count elements of list lst

Result type: (:uniform-list %type)

Purity of the procedure: pure

If `count` is larger than the length of `lst` an exception is raised.

drop-right

Syntax:

```
(drop-right lst count)
```

Type parameters: `%type`

Arguments:

Name: `lst`
Type: `(:uniform-list %type)`
Description: A list

Name: `count`
Type: `<integer>`
Description: Number of elements to be dropped

Result value: A list constructed by dropping away the last `count` elements of list `lst`

Result type: `(:uniform-list %type)`

Purity of the procedure: pure

If `count` is larger than the length of `lst` an exception is raised.

take

Syntax:

```
(take lst count)
```

Type parameters: `%type`

Arguments:

Name: `lst`
Type: `(:uniform-list %type)`
Description: A list

Name: `count`
Type: `<integer>`
Description: Number of elements to be taken

Result value: A list containing the first `count` elements of list `lst`

Result type: `(:uniform-list %type)`

Purity of the procedure: pure

If `count` is larger than the length of `lst` an exception is raised.

take-right

Syntax:

```
(take-right lst count)
```

Type parameters: `%type`

Arguments:

Name: `lst`
Type: `(:uniform-list %type)`
Description: A list

Name: `count`
Type: `<integer>`
Description: Number of elements to be taken

Result value: A list containing the last `count` elements of list `lst`

Result type: `(:uniform-list %type)`

Purity of the procedure: pure

If `count` is larger than the length of `lst` an exception is raised.

last

Syntax:

```
(last lst)
```

Type parameters: `%type`

Arguments:

Name: `lst`
Type: `(:nonempty-uniform-list %type)`

Description: A nonempty list

Result value: The last element of the list `lst`

Result type: `%type`

Purity of the procedure: pure

for-each

Syntax:

```
(for-each proc lst-1 ... lst-n)
```

Type parameters: `%arglist`

Arguments:

Name: `proc`

Type: `(:procedure ((splice %arglist)) <none> nonpure)`

Description: A procedure to apply

Name: `lst-k`

Type: `(:uniform-list t_k)`

Description: A list to take arguments from

No result value.

Purity of the procedure: nonpure

The semantics resembles Scheme `for-each`. Procedure `proc` is applied to the j th elements of the `lst-k`'s for each $j = 1, \dots, m$ (in this order) where m is the minimum of the lengths of `lst-k`'s. You may use a procedure with result type `<none>` as the first argument to `for-each`. The value of the type parameter `%arglist` is a tuple type consisting of types t_k , $k = 1, \dots, n$. Procedure `proc` takes arguments with types t_k , $k = 1, \dots, n$.

for-each1

Syntax:

```
(for-each1 proc lst)
```

Type parameters: `%arg-type`

Arguments:

Name: `proc`
 Type: `(:procedure (%arg-type) <none> nonpure)`
 Description: A procedure to apply

Name: `lst`
 Type: `(:uniform-list %arg-type)`
 Description: Values to which the procedure is applied

No result value.

Purity of the procedure: nonpure

The semantics resembles Scheme `for-each`. You may use a procedure with result type `<none>` as the first argument to `for-each`.

map

Syntax:

```
(map proc lst-1 ... lst-n)
```

Type parameters: `%arglist`, `%result-type`

Arguments:

Name: `proc`
 Type: `(:procedure ((splice %arglist)) %result-type pure)`
 Description: A procedure to apply

Name: `lst-k`
 Type: `(:uniform-list t_k)`
 Description: Lists to take arguments from

Result value: A list constructed by applying `proc` to the j th elements of the `lst-k`'s for each $j = 1, \dots, m$ where m is the minimum of the list lengths

Result type: `(:uniform-list %result-type)`

Purity of the procedure: pure

The semantics resembles Scheme `map`. The value of the type parameter `%arglist` is a tuple type consisting of types t_k , $k = 1, \dots, n$. Note that you cannot use procedure with result type `<none>` as the first argument of `map`.

map1

Syntax:

```
(map1 proc lst)
```

Type parameters: %arg-type, %result-type

Arguments:

Name: `proc`
 Type: `(:procedure (%arg-type) %result-type pure)`
 Description: A procedure to apply

Name: `lst`
 Type: `(:uniform-list %arg-type)`
 Description: Values to which the procedure is applied

Result value: A list constructed by applying `proc` to the elements of list `lst`
Result type: `(:uniform-list %result-type)`

Purity of the procedure: pure

The semantics resembles Scheme `map`. Note that you cannot use procedure with result type `<none>` as the first argument of `map1`.

map-nonpure

Syntax:

```
(map-nonpure proc lst-1 ... lst-n)
```

Type parameters: %arglist, %result-type

Arguments:

Name: `proc`
 Type: `(:procedure ((splice %arglist)) %result-type nonpure)`
 Description: A procedure to apply

Name: `lst-k`
 Type: `(:uniform-list t_k)`
 Description: A list to take arguments from

Result value: A list constructed by applying `proc` to the j th elements of the `lst-k`'s for each $j = 1, \dots, m$ where m is the minimum of the list lengths
Result type: `(:uniform-list %result-type)`

Purity of the procedure: nonpure

The semantics of `map-nonpure` resemble `map` except `proc` may be nonpure and the applications of `proc` are guaranteed to be done in the order of increasing j . The value of the type parameter `%arglist` is a tuple type consisting of types t_k , $k = 1, \dots, n$. Note that you cannot use procedure with result type `<none>` as the first argument of `map-nonpure`.

map-nonpure1

Syntax:

```
(map-nonpure1 proc lst)
```

Type parameters: `%arg-type`, `%result-type`

Arguments:

Name: `proc`
 Type: `(:procedure (%arg-type) %result-type nonpure)`
 Description: A procedure to apply

Name: `lst`
 Type: `(:uniform-list %arg-type)`
 Description: Values to which the procedure is applied

Result value: A list constructed by applying `proc` to the elements of list `lst`

Result type: `(:uniform-list %result-type)`

Purity of the procedure: `nonpure`

The semantics resembles Scheme `map`. Note that you cannot use procedure with result type `<none>` as the first argument of `map-nonpure1`.

and-map?

Syntax:

```
(and-map? proc lst-1 ... lst-n)
```

Type parameters: `%arglist`

Arguments:

Name: `proc`
 Type: `(:procedure ((splice %arglist)) <boolean> pure)`
 Description: A procedure to apply

Name: `lst-k`
 Type: `(:uniform-list tk)`
 Description: Lists to take arguments from

Result value: `#t` iff `proc` returns `#t` for each elementwise application to lists `lst-k`

Result type: `<boolean>`

Purity of the procedure: pure

Note that if any of the applications of `proc` returns `#f` the rest of the elements are not evaluated. If the lengths of the lists are different the number of evaluations is the length of the shortest list. If all the argument lists are `null` return `#t`. The value of the type parameter `%arglist` is a tuple type consisting of types t_k , $k = 1, \dots, n$. Procedure `proc` takes arguments with types t_k , $k = 1, \dots, n$.

and-map1?

Syntax:

```
(and-map1? proc lst)
```

Type parameters: `%argtype`

Arguments:

Name: `proc`
 Type: `(:procedure (%argtype)) <boolean> pure`
 Description: A procedure to apply

Name: `lst`
 Type: `(:uniform-list %argtype)`
 Description: A list to take arguments from

Result value: `#t` iff `proc` returns `#t` for each application to the elements of list `lst`

Result type: `<boolean>`

Purity of the procedure: pure

Note that if any of the applications of `proc` returns `#f` the rest of the elements are not evaluated. If `lst` is `null` return `#t`.

and-map-nonpure?

Syntax:

```
(and-map-nonpure? proc lst-1 ... lst-n)
```

Type parameters: %arglist

Arguments:

Name: `proc`
 Type: `(:procedure ((splice %arglist)) <boolean> nonpure)`
 Description: A procedure to apply

Name: `lst-k`
 Type: `(:uniform-list t_k)`
 Description: Lists to take arguments from

Result value: #t iff `proc` returns #t for each elementwise application to lists `lst-k`

Result type: <boolean>

Purity of the procedure: nonpure

This procedure is similar to `and-map?` except that `proc` may have side effects.

and-map-nonpure1?

Syntax:

```
(and-map-nonpure1? proc lst)
```

Type parameters: %argtype

Arguments:

Name: `proc`
 Type: `(:procedure (%argtype)) <boolean> nonpure)`
 Description: A procedure to apply

Name: `lst`
 Type: `(:uniform-list %argtype)`
 Description: A list to take arguments from

Result value: #t iff `proc` returns #t for each application to the elements of list `lst`

Result type: <boolean>

Purity of the procedure: nonpure

This procedure is similar to `and-map1?` except that `proc` may have side effects.

or-map?

Syntax:

```
(or-map? proc lst-1 ... lst-n)
```

Type parameters: `%arglist`

Arguments:

Name: `proc`
 Type: `(:procedure ((splice %arglist)) <boolean> pure)`
 Description: A procedure to apply

Name: `lst-k`
 Type: `(:uniform-list t_k)`
 Description: Lists to take arguments from

Result value: `#t` iff `proc` returns `#t` for any elementwise application to lists `lst-k`

Result type: `<boolean>`

Purity of the procedure: pure

The value of the type parameter `%arglist` is a tuple type consisting of types t_k , $k = 1, \dots, n$. Procedure `proc` takes arguments with types t_k , $k = 1, \dots, n$. Note that if any of the applications of `proc` returns `#t` the rest of the elements are not evaluated. If the lengths of the lists are different the number of evaluations is the length of the shortest list. If all the argument lists are `null` return `#f`.

or-map1?

Syntax:

```
(or-map1? proc lst)
```

Type parameters: `%argtype`

Arguments:

Name: `proc`
 Type: `(:procedure (%argtype)) <boolean> pure`
 Description: A procedure to apply

Name: `lst`
 Type: `(:uniform-list %argtype)`
 Description: A list to take arguments from

Result value: `#t` iff `proc` returns `#t` for some application to the elements of list `lst`

Result type: `<boolean>`

Purity of the procedure: pure

Note that if any of the applications of `proc` returns `#t` the rest of the elements are not evaluated. If `lst` is null return `#f`.

`or-map-nonpure?`

Syntax:

```
(or-map-nonpure? proc lst-1 ... lst-n)
```

Type parameters: `%arglist`

Arguments:

Name: `proc`
 Type: `(:procedure ((splice %arglist)) <boolean> nonpure)`
 Description: A procedure to apply

Name: `lst-k`
 Type: `(:uniform-list t_k)`
 Description: Lists to take arguments from

Result value: `#t` iff `proc` returns `#t` for any elementwise application to lists `lst-k`

Result type: `<boolean>`

Purity of the procedure: nonpure

This procedure is similar to `or-map?` except that `proc` may have side effects.

`or-map-nonpure1?`

Syntax:

```
(or-map-nonpure1? proc lst)
```

Type parameters: %argtype

Arguments:

Name: `proc`
 Type: `(:procedure (%argtype)) <boolean> nonpure`
 Description: A procedure to apply

Name: `lst`
 Type: `(:uniform-list %argtype)`
 Description: A list to take arguments from

Result value: #t iff `proc` returns #t for some application to the elements of list `lst`

Result type: <boolean>

Purity of the procedure: nonpure

This procedure is similar to `or-map1?` except that `proc` may have side effects.

map-car

Syntax:

```
(map-car lst)
```

Type parameters: %arglist

Arguments:

Name: `lst`
 Type: `(:tuple (:nonempty-uniform-list t1) ... (:nonempty-uniform-list tn))`
 Description: Lists to take arguments from

Result value: A list constructed by taking the first element of each component list of `lst`

Result type: %arglist

Purity of the procedure: pure

The value of the type parameter `%arglist` is a tuple type consisting of types t_k , $k = 1, \dots, n$.

map-cdr

Syntax:

```
(map-cdr lst)
```

Type parameters: `%arglist`

Arguments:

Name: `lst`
 Type: `(:tuple (:nonempty-uniform-list t_1) ... (:nonempty-uniform-list t_n))`
 Description: Lists to take arguments from

Result value: A list constructed by taking the tail of each component list of `lst`

Result type: `(type-loop %type %arglist (:uniform-list %type))`

Purity of the procedure: pure

The value of the type parameter `%arglist` is a tuple type consisting of types t_k , $k = 1, \dots, n$.

assoc-general

Syntax:

```
(assoc-general key association-list default my-eq?)
```

Type parameters: `%type1`, `%type2`, `%default`

Arguments:

Name: `key`
 Type: `%type1`
 Description: the key to be searched

Name: `association-list`
 Type: `(:a-list %type1 %type2)`
 Description: the association list to be searched

Name: `default`

Type: `%default`

Description: the value returned if no association is found

Name: `my-eq?`

Type: `(:procedure (%type1 %type1) <boolean> pure)`

Description: the equivalence predicate to be used in the search

Result value: The result of the search

Result type: `(:union (:pair %type1 %type2) %default)`

Purity of the procedure: pure

The association list `association-list` is searched for `key`. If `key` is found return the first association having the key. Otherwise return `default`. The keys are compared with the equivalence predicate `my-eq?`.

ASSOC

Syntax:

```
(assoc key association-list default)
```

Type parameters: `%type1`, `%type2`, `%default`

Arguments:

Name: `key`

Type: `%type1`

Description: the key to be searched

Name: `association-list`

Type: `(:a-list %type1 %type2)`

Description: the association list to be searched

Name: `default`

Type: `%default`

Description: the value returned if no association is found

Result value: The result of the search

Result type: `(:union (:pair %type1 %type2) %default)`

Purity of the procedure: pure

The association list `association-list` is searched for `key`. If `key` is found return the first association having the key. Otherwise return `default`. The keys are compared with the equivalence predicate `equal?`.

assoc-objects*Syntax:*`(assoc-objects key association-list default)`*Type parameters:* `%type1, %type2, %default`*Arguments:*Name: `key`Type: `%type1`

Description: the key to be searched

Name: `association-list`Type: `(:a-list %type1 %type2)`

Description: the association list to be searched

Name: `default`Type: `%default`

Description: the value returned if no association is found

Result value: The result of the search*Result type:* `(:union (:pair %type1 %type2) %default)`*Purity of the procedure:* pure

The association list `association-list` is searched for `key`. If `key` is found return the first association having the key. Otherwise return `default`. The keys are compared with the equivalence predicate `equal-objects?`.

assoc-contents*Syntax:*`(assoc-contents key association-list default)`*Type parameters:* `%type1, %type2, %default`*Arguments:*Name: `key`Type: `%type1`

Description: the key to be searched

Name: `association-list`

Type: (:a-list %type1 %type2)
 Description: the association list to be searched

Name: `default`
 Type: %default
 Description: the value returned if no association is found

Result value: The result of the search

Result type: (:union (:pair %type1 %type2) %default)

Purity of the procedure: pure

The association list `association-list` is searched for `key`. If `key` is found return the first association having the key. Otherwise return `default`. The keys are compared with the equivalence predicate `equal-contents?`.

a-list-delete

Syntax:

```
(a-list-delete key association-list my-eq?)
```

Type parameters: %type1, %type2

Arguments:

Name: `key`
 Type: %type1
 Description: the key to be searched

Name: `association-list`
 Type: (:a-list %type1 %type2)
 Description: the association list to be searched

Name: `my-eq?`
 Type: (:procedure (%type1 %type1) <boolean> pure)
 Description: the equivalence predicate to be used in the search

Result value: The association list obtained by removing all bindings for key `key` from `association-list`

Result type: (:a-list %type1 %type2)

Purity of the procedure: pure

member-general?

Syntax:

```
(member-general? object lst my-eq?)
```

Type parameters: %type

Arguments:

Name: `object`
 Type: %type
 Description: the object to be searched

Name: `lst`
 Type: (:uniform-list %type)
 Description: the list to be searched

Name: `my-eq?`
 Type: (:procedure (%type %type) <boolean> pure)
 Description: equivalence predicate to be used in the search

Result value: Result of the search

Result type: <boolean>

Purity of the procedure: pure

The list `lst` is searched for `object`. If `object` is found return `#t`. Otherwise return `#f`. The list items are compared with the equivalence predicate `my-eq?`.

member?

Syntax:

```
(member? object lst)
```

Type parameters: %type

Arguments:

Name: `object`
 Type: %type
 Description: the object to be searched

Name: `lst`
 Type: (:uniform-list %type)
 Description: the list to be searched

Result value: Result of the search

Result type: <boolean>

Purity of the procedure: pure

The list `lst` is searched for `object`. If `object` is found return `#t`. Otherwise return `#f`. The list items are compared with the equivalence predicate `equal?`.

member-objects?

Syntax:

```
(member-objects? object lst)
```

Type parameters: %type

Arguments:

Name: `object`
 Type: %type
 Description: the object to be searched

Name: `lst`
 Type: (:uniform-list %type)
 Description: the list to be searched

Result value: Result of the search

Result type: <boolean>

Purity of the procedure: pure

The list `lst` is searched for `object`. If `object` is found return `#t`. Otherwise return `#f`. The list items are compared with the equivalence predicate `equal-objects?`.

member-contents?

Syntax:

```
(member-contents? object lst)
```

Type parameters: %type

Arguments:

Name: `object`

Type: `%type`
 Description: the object to be searched

Name: `lst`
 Type: `(:uniform-list %type)`
 Description: the list to be searched

Result value: Result of the search

Result type: `<boolean>`

Purity of the procedure: pure

The list `lst` is searched for `object`. If `object` is found return `#t`. Otherwise return `#f`. The list items are compared with the equivalence predicate `equal-contents?`.

append

Syntax:

```
(append list-1 ... list-n)
```

Type parameters: `%types`

Arguments:

Name: `list-k`
 Type: `(:uniform-list tk)`
 Description: A list to be merged

Result value: A list constructed by appending the arguments

Result type: `(:uniform-list (:union t1 ... tn))`

Purity of the procedure: pure

append-tuples

Syntax:

```
(append-tuples tuple-1 ... tuple-n)
```

Type parameters: `%tuples`

Arguments:

Name: `tuple-k`
 Type: `(:tuple tk,1 ... tk,m(k))`
 Description: A tuple to be merged

Result value: A tuple constructed by appending the arguments

Result type: `(:tuple t1,1 ... t1,m(1) ... tn,1 ... tn,m(n))`

Purity of the procedure: pure

reverse

Syntax:

`(reverse lst)`

Type parameters: `%type`

Arguments:

Name: `lst`
 Type: `(:uniform-list %type)`
 Description: A list to be reversed

Result value: A list constructed by reversing the argument list

Result type: `(:uniform-list %type)`

Purity of the procedure: pure

uniform-list-ref

Syntax:

`(uniform-list-ref lst index)`

Type parameters: `%type`

Arguments:

Name: `lst`
 Type: `(:uniform-list %type)`
 Description: A uniform list

Name: `index`
 Type: `<integer>`
 Description: Index to the list

Result value: Element of `lst` at position `index`
Result type: `%type`

Purity of the procedure: pure

The indices start from zero.

filter

Syntax:

```
(filter pred lst)
```

Type parameters: `%type`

Arguments:

Name: `pred`
 Type: `(:procedure (%type) <boolean> pure)`
 Description: the predicate used for picking the elements

Name: `lst`
 Type: `(:uniform-list %type)`
 Description: The list to be searched

Result value: The list computed by picking all the elements in `lst` for which `pred` returns `#t`
Result type: `(:uniform-list %type)`

Purity of the procedure: pure

distinct-elements?

Syntax:

```
(distinct-elements? lst my-eq?)
```

Type parameters: `%type`

Arguments:

Name: `lst`
Type: `(:uniform-list %type)`
Description: The list to be checked

Name: `my-eq?`
Type: `(:procedure (%type %type) <boolean> pure)`
Description: the equivalence predicate used for checking the elements

Result value: `#t` iff no two elements of `lst` are equal by `my-eq?`

Result type: `<boolean>`

Purity of the procedure: `pure`

3.6 Logical Operations

3.6.1 Simple Procedures

`not`

Syntax:

`(not boolean-value)`

Arguments:

Name: `boolean-value`
Type: `<boolean>`
Description: A boolean value

Result value: `#t` iff the value of `boolean-value` is `#f`

Result type: `<boolean>`

Purity of the procedure: `pure`

`not-object`

Syntax:

`(not-object obj)`

Arguments:

Name: `obj`
Type: `<object>`
Description: Any object

Result value: `#t` iff `obj` is false, `#f` otherwise
Result type: `<boolean>`

Purity of the procedure: pure

XOR

Syntax:

```
(xor boolean-value1 boolean-value2)
```

Arguments:

Name: `boolean-value1`
Type: `<boolean>`
Description: A boolean value

Name: `boolean-value2`
Type: `<boolean>`
Description: A boolean value

Result value: `#t` iff exactly one of the values `boolean-value1` and `boolean-value2` is `#t`
Result type: `<boolean>`

Purity of the procedure: pure

3.7 Strings

3.7.1 Data Types

Data type name: `<string-match-result>`
Type: `:union`
Description: Return value of procedure `string-match`

3.7.2 Simple Procedures

replace-char

Syntax:

```
(replace-char str ch-src ch-dest)
```

Arguments:

Name: `str`
Type: `<string>`
Description: A string

Name: `ch-src`
Type: `<character>`
Description: The character to be replaced

Name: `ch-dest`
Type: `<character>`
Description: The destination character

Result value: A string obtained by replacing character `ch-src` with `ch-dest` in string `str`

Result type: `<string>`

Purity of the procedure: pure

replace-char-with-string

Syntax:

```
(replace-char-with-string str ch-src str-dest)
```

Arguments:

Name: `str`
Type: `<string>`
Description: A string

Name: `ch-src`
Type: `<character>`
Description: The character to be replaced

Name: `str-dest`
Type: `<string>`
Description: The destination string

Result value: A string obtained by replacing character `ch-src` with `str-dest` in string `str`

Result type: `<string>`

Purity of the procedure: pure

join-strings-with-sep

Syntax:

```
(join-strings-with-sep lst str-separator)
```

Arguments:

Name: `lst`
Type: `(:uniform-list <string>)`
Description: A list of strings to join

Name: `str-separator`
Type: `<string>`
Description: The separator

Result value: A string obtained to join the strings in `lst` in order

Result type: `<string>`

Purity of the procedure: pure

search-substring

Syntax:

```
(search-substring str str-match)
```

Arguments:

Name: `str`
Type: `<string>`
Description: A string

Name: `str-match`
Type: `<string>`
Description: The string to be searched

Purity of the procedure: pure

Result value: Index of the first occurrence of string `str-match` in string `str` (-1 if the string is not found)

Result type: `<integer>`

search-substring-from-end

Syntax:

```
(search-substring-from-end str str-match)
```

Arguments:

Name: `str`
Type: `<string>`
Description: A string

Name: `str-match`
Type: `<string>`
Description: The string to be searched

Purity of the procedure: pure

Result value: Search for string `str-match` in string `str` starting from the end of `str` and return the index of the first match (-1 if the search does not succeed)

Result type: `<integer>`

split-string

Syntax:

```
(split-string str ch)
```

Arguments:

Name: `str`
Type: `<string>`
Description: A string to be split

Name: `ch`
Type: `<character>`
Description: The separator character

Result value: A list constructed by splitting the string `str`

Result type: `(:uniform-list <string>)`

Purity of the procedure: pure

The character `ch` is used as a separator in splitting.

string

Syntax:

```
(string char-1 ... char-n)
```

Arguments:

Name: `char-k`
Type: `<character>`
Description: A character

Result value: A string consisting of characters `char-1 ... char-n`

Result type: `<string>`

Purity of the procedure: pure

string->symbol

Syntax:

```
(string->symbol str)
```

Arguments:

Name: `str`
Type: `<string>`
Description: A string

Result value: The argument string converted to a symbol

Result type: `<symbol>`

Purity of the procedure: pure

string-append

Syntax:

```
(string-append str-1 ... str-n)
```

Arguments:

Name: `str-k`
Type: `<string>`
Description: A string

Purity of the procedure: pure

Result value: A string obtained by concatenating strings `str-1 ... str-n`

Result type: `<string>`

string-char-index

Syntax:

```
(string-char-index str ch)
```

Arguments:

Name: `str`
Type: `<string>`
Description: A string

Name: `ch`
Type: `<character>`
Description: A character to be searched

Purity of the procedure: pure

Result value: Index of the first occurrence of character `ch` in string `str` (-1 if the character is not found)

Result type: `<integer>`

string-char-index-right

Syntax:

```
(string-char-index-right str ch)
```

Arguments:

Name: `str`
Type: `<string>`
Description: A string

Name: `ch`
Type: `<character>`
Description: A character to be searched

Purity of the procedure: pure

Result value: Index of the last occurrence of character `ch` in string `str` (-1 if the character is not found)

Result type: `<integer>`

string-contains-char?

Syntax:

```
(string-contains-char? str ch)
```

Arguments:

Name: `str`
Type: `<string>`
Description: A string

Name: `ch`
Type: `<character>`
Description: A character

Purity of the procedure: pure

Result value: `#t` iff string `str` contains character `ch`

Result type: `<boolean>`

string-drop

Syntax:

```
(string-drop str count)
```

Arguments:

Name: `str`
Type: `<string>`
Description: A string

Name: `count`
Type: `<integer>`
Description: Number of characters to be dropped

Result value: A string constructed of by dropping away the first `count` characters of `str`

Result type: `<string>`

Purity of the procedure: pure

If `count` is larger than the length of `str` an exception is raised.

string-drop-right

Syntax:

```
(string-drop-right str count)
```

Arguments:

Name: `str`
Type: `<string>`
Description: A string

Name: `count`
Type: `<integer>`
Description: Number of characters to be dropped

Result value: A string constructed of by dropping away the last `count` characters of `str`

Result type: `<string>`

Purity of the procedure: pure

If `count` is larger than the length of `str` an exception is raised.

string-empty?

Syntax:

```
(string-empty? str)
```

Arguments:

Name: `str`
Type: `<string>`
Description: A string

Result value: `#t` iff the string is empty

Result type: `<boolean>`

Purity of the procedure: pure

string-exact-match?

Syntax:

```
(string-exact-match? str-pattern str-source)
```

Arguments:

Name: `str-pattern`
Type: `<string>`
Description: A pattern

Name: `str-source`
Type: `<string>`
Description: The source string for matching

Result value: `#t` iff the pattern matches the whole source string

Result type: `<boolean>`

Purity of the procedure: pure

string-last-char

Syntax:

```
(string-last-char str)
```

Arguments:

Name: `str`
Type: `<string>`
Description: A string

Result value: The last character of the string `str`

Result type: `<character>`

Purity of the procedure: pure

If `str` is empty raise an exception.

string-length

Syntax:

```
(string-length str)
```

Arguments:

Name: `str`
Type: `<string>`
Description: A string

Result value: The length of the string `str`

Result type: `<integer>`

Purity of the procedure: pure

string-match

Syntax:

```
(string-match str-pattern str-source)
```

Arguments:

Name: `str-pattern`
Type: `<string>`
Description: A pattern

Name: `str-source`
Type: `<string>`

Description: The source string for matching

Result value: The results of the matching

Result type: <string-match-results>

Purity of the procedure: pure

If the matching fails return `null`. Otherwise the result is a tuple consisting of three elements: the first element is the substring to which the pattern matched, the second item is the index to the source string where the matching started, and the third item the index where the matching stopped.

string-ref

Syntax:

```
(string-ref str index)
```

Arguments:

Name: `str`

Type: <string>

Description: A string

Name: `index`

Type: <integer>

Description: An index to the string

Result value: The character at the `index`th position of string `str`

Result type: <character>

Purity of the procedure: pure

string-take

Syntax:

```
(string-take str count)
```

Arguments:

Name: `str`

Type: <string>

Description: A string

Name: `count`
Type: `<integer>`
Description: Number of characters to be taken

Result value: A string consisting of the first `count` characters of `str`
Result type: `<string>`

Purity of the procedure: pure

If `count` is larger than the length of `str` an exception is raised.

`string-take-right`

Syntax:

```
(string-take-right str count)
```

Arguments:

Name: `str`
Type: `<string>`
Description: A string

Name: `count`
Type: `<integer>`
Description: Number of characters to be taken

Result value: A string consisting of the last `count` characters of `str`
Result type: `<string>`

Purity of the procedure: pure

If `count` is larger than the length of `str` an exception is raised.

`substring`

Syntax:

```
(substring str i-start i-end)
```

Arguments:

Name: `str`
Type: `<string>`

Description: A string

Name: `i-start`

Type: `<integer>`

Description: Index from which to start the extraction

Name: `i-end`

Type: `<integer>`

Description: Index to which to stop the extraction

Result value: A substring of `str`

Result type: `<integer>`

Purity of the procedure: pure

Note that the character at the position `i-end` is not included in the substring.

3.8 Vectors

3.8.1 Parametrized Procedures

`mutable-value-vector-length`

Syntax:

```
(mutable-value-vector-length vec)
```

Type parameters: `%type`

Arguments:

Name: `vec`

Type: `(:mutable-value-vector %type)`

Description: A vector

Result value: Length of the vector `vec`

Result type: `<integer>`

Purity of the procedure: pure

`mutable-value-vector-ref`

Syntax:

```
(mutable-value-vector-ref vec index)
```

Type parameters: %type

Arguments:

Name: `vec`
Type: `(:mutable-value-vector %type)`
Description: A vector

Name: `index`
Type: `<integer>`
Description: Index to the vector

Result value: Element of vector `vec` at the position `index`

Result type: %type

Purity of the procedure: pure

mutable-value-vector-set!

Syntax:

```
(mutable-value-vector-set! vec index element)
```

Type parameters: %type

Arguments:

Name: `vec`
Type: `(:mutable-value-vector %type)`
Description: A vector

Name: `index`
Type: `<integer>`
Description: Index to the vector

Name: `element`
Type: %type
Description: The new value of the element

No result value.

Purity of the procedure: nonpure

mutable-vector-length

Syntax:

```
(mutable-vector-length vec)
```

Type parameters: %type

Arguments:

Name: `vec`
Type: `(:mutable-vector %type)`
Description: A vector

Result value: Length of the vector `vec`

Result type: `<integer>`

Purity of the procedure: pure

mutable-vector-ref

Syntax:

```
(mutable-vector-ref vec index)
```

Type parameters: %type

Arguments:

Name: `vec`
Type: `(:mutable-vector %type)`
Description: A vector

Name: `index`
Type: `<integer>`
Description: Index to the vector

Result value: Element of vector `vec` at the position `index`

Result type: %type

Purity of the procedure: pure

mutable-vector-set!

Syntax:

```
(mutable-vector-set! vec index element)
```

Type parameters: %type

Arguments:

Name: `vec`
Type: `(:mutable-vector %type)`
Description: A vector

Name: `index`
Type: `<integer>`
Description: Index to the vector

Name: `element`
Type: %type
Description: The new value of the element

No result value.

Purity of the procedure: nonpure

value-vector-length

Syntax:

```
(value-vector-length vec)
```

Type parameters: %type

Arguments:

Name: `vec`
Type: `(:value-vector %type)`
Description: A vector

Result value: Length of the vector `vec`

Result type: `<integer>`

Purity of the procedure: pure

value-vector-ref

Syntax:

```
(value-vector-ref vec index)
```

Type parameters: %type

Arguments:

Name: `vec`
Type: `(:value-vector %type)`
Description: A vector

Name: `index`
Type: `<integer>`
Description: Index to the vector

Result value: Element of vector `vec` at the position `index`

Result type: %type

Purity of the procedure: pure

vector-length

Syntax:

```
(vector-length vec)
```

Type parameters: %type

Arguments:

Name: `vec`
Type: `(:vector %type)`
Description: A vector

Result value: Length of the vector `vec`

Result type: `<integer>`

Purity of the procedure: pure

vector-ref

Syntax:

```
(vector-ref vec index)
```

Type parameters: %type

Arguments:

Name: `vec`
Type: `(:vector %type)`
Description: A vector

Name: `index`
Type: `<integer>`
Description: Index to the vector

Result value: Element of vector `vec` at the position `index`

Result type: %type

Purity of the procedure: pure

3.9 Arithmetic Operations

3.9.1 Simple Procedures

ceiling

Syntax:

```
(ceiling r)
```

Arguments:

Name: `r`
Type: `<real>`
Description: A real number

Result value: Rounded value

Result type: `<integer>`

Purity of the procedure: pure

This procedure rounds a real number towards infinity.

factorial

Syntax:

(factorial i)

Arguments:

Name: i

Type: <integer>

Description: A nonnegative integer number

Result value: The factorial of the argument

Result type: <integer>

Purity of the procedure: pure

finite?

Syntax:

(finite? r)

Arguments:

Name: r

Type: <real>

Description: A real number

Result value: Returns #t iff r is a finite value

Result type: <boolean>

Purity of the procedure: pure

floor

Syntax:

(floor r)

Arguments:

Name: r

Type: `<real>`
Description: A real number

Result value: Rounded value
Result type: `<integer>`

Purity of the procedure: pure

This procedure rounds a real number towards minus infinity.

gcd

Syntax:

```
(gcd i1 i2)
```

Arguments:

Name: `i1`
Type: `<integer>`
Description: An integer number

Name: `i2`
Type: `<integer>`
Description: An integer number

Result value: The greatest common divisor of the arguments
Result type: `<integer>`

Purity of the procedure: pure

i-log10-exact

Syntax:

```
(i-log10-exact i)
```

Arguments:

Name: `i`
Type: `<integer>`
Description: A positive integer number

Result value: The base 10 logarithm of the argument or `null` if the logarithm

is not an integer

Result type: (:maybe <integer>)

Purity of the procedure: pure

i-log2-exact

Syntax:

```
(i-log2-exact i)
```

Arguments:

Name: i

Type: <integer>

Description: A positive integer number

Result value: The base 2 logarithm of the argument or null if the logarithm is not an integer

Result type: (:maybe <integer>)

Purity of the procedure: pure

infinite?

Syntax:

```
(infinite? r)
```

Arguments:

Name: r

Type: <real>

Description: A real number

Result value: Returns #t iff r is an infinite value

Result type: <boolean>

Purity of the procedure: pure

integer+

Syntax:

```
(integer+ int1 int2)
```

Arguments:

Name: `int1`
Type: `<integer>`
Description: An integer value

Name: `int2`
Type: `<integer>`
Description: An integer value

Result value: The sum of the arguments

Result type: `<integer>`

Purity of the procedure: pure

`integer-`

Syntax:

```
(integer- int1 int2)
```

Arguments:

Name: `int1`
Type: `<integer>`
Description: An integer value

Name: `int2`
Type: `<integer>`
Description: An integer value

Result value: The difference of the arguments

Result type: `<integer>`

Purity of the procedure: pure

`integer*`

Syntax:

```
(integer* int1 int2)
```

Arguments:

Name: `int1`
Type: `<integer>`
Description: An integer value

Name: `int2`
Type: `<integer>`
Description: An integer value

Result value: The product of the arguments

Result type: `<integer>`

Purity of the procedure: pure

`integer<`

Syntax:

```
(integer< int1 int2)
```

Arguments:

Name: `int1`
Type: `<integer>`
Description: An integer value

Name: `int2`
Type: `<integer>`
Description: An integer value

Result value: `#t` iff `int1 < int2`

Result type: `<boolean>`

Purity of the procedure: pure

`integer>`

Syntax:

```
(integer> int1 int2)
```

Arguments:

Name: `int1`
Type: `<integer>`
Description: An integer value

Name: `int2`
Type: `<integer>`
Description: An integer value

Result value: `#t` iff `int1 > int2`

Result type: `<boolean>`

Purity of the procedure: pure

`integer>=`

Syntax:

`(integer>= int1 int2)`

Arguments:

Name: `int1`
Type: `<integer>`
Description: An integer value

Name: `int2`
Type: `<integer>`
Description: An integer value

Result value: `#t` iff `int1 ≥ int2`

Result type: `<boolean>`

Purity of the procedure: pure

`integer<=`

Syntax:

`(integer<= int1 int2)`

Arguments:

Name: `int1`
Type: `<integer>`
Description: An integer value

Name: `int2`
Type: `<integer>`
Description: An integer value

Result value: `#t` iff `int1 ≤ int2`

Result type: `<boolean>`

Purity of the procedure: pure

`integer->real`

Syntax:

`(integer->real int)`

Arguments:

Name: `int`
Type: `<integer>`
Description: An integer value

Result value: The integer value converted to a real value

Result type: `<real>`

Purity of the procedure: pure

`i-abs`

Syntax:

`(i-abs n)`

Arguments:

Name: `n`
Type: `<integer>`
Description: An integer number

Result value: Absolute value of the argument

Result type: <integer>

Purity of the procedure: pure

i-nonneg-expt

Syntax:

```
(i-nonneg-expt i-base i-expt)
```

Arguments:

Name: **i-base**
Type: <integer>
Description: An integer number

Name: **i-expt**
Type: <integer>
Description: A nonnegative integer number

Result value: **i-base** raised to the power **i-expt**

Result type: <integer>

Purity of the procedure: pure

i-sign

Syntax:

```
(i-sign i)
```

Arguments:

Name: **i**
Type: <integer>
Description: An integer number

Result value: Return 0 if **i** = 0, 1 if **i** > 0, and -1 if **i** < 0

Result type: <integer>

Purity of the procedure: pure

i-square

Syntax:

(i-square n)

Arguments:

Name: n
Type: <integer>
Description: An integer number

Result value: Square of the argument

Result type: <integer>

Purity of the procedure: pure

inf

Syntax:

(inf)

No arguments.

Result value: The exceptional floating point value inf (positive infinity)

Result type: <real>

Purity of the procedure: pure

integer-float?

Syntax:

(integer-float? r)

Arguments:

Name: r
Type: <real>
Description: A real number

Result value: #t iff *r* is an integer value

Result type: <integer>

Purity of the procedure: pure

i-neg

Syntax:

(i-neg *n*)

Arguments:

Name: *n*

Type: <integer>

Description: An integer number

Result value: The opposite number of the argument

Result type: <integer>

Purity of the procedure: pure

integer-real+

Syntax:

(integer-real+ *i r*)

Arguments:

Name: *i*

Type: <integer>

Description: An integer value

Name: *r*

Type: <real>

Description: A real value

Result value: The sum of the arguments

Result type: <real>

Purity of the procedure: pure

integer-real-

Syntax:

(integer-real- i r)

Arguments:

Name: i
Type: <integer>
Description: An integer value

Name: r
Type: <real>
Description: A real value

Result value: The difference of the arguments

Result type: <integer>

Purity of the procedure: pure

integer-real*

Syntax:

(integer-real* i r)

Arguments:

Name: i
Type: <integer>
Description: An integer value

Name: r
Type: <real>
Description: A real value

Result value: The product of the arguments

Result type: <real>

Purity of the procedure: pure

integer-real/

Syntax:

(integer-real/ i r)

Arguments:

Name: i
Type: <integer>
Description: An integer value

Name: r
Type: <real>
Description: A real value

Result value: The quotient of the arguments

Result type: <real>

Purity of the procedure: pure

integer-real<

Syntax:

(integer-real< i r)

Arguments:

Name: i
Type: <integer>
Description: An integer value

Name: r
Type: <real>
Description: A real value

Result value: #t iff $i < r$

Result type: <boolean>

Purity of the procedure: pure

integer-real<=

Syntax:

`(integer-real<= i r)`

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer value

Name: `r`
Type: `<real>`
Description: A real value

Result value: `#t` iff `i <= r`

Result type: `<boolean>`

Purity of the procedure: pure

`integer-real>`

Syntax:

`(integer-real> i r)`

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer value

Name: `r`
Type: `<real>`
Description: A real value

Result value: `#t` iff `i > r`

Result type: `<boolean>`

Purity of the procedure: pure

`integer-real>=`

Syntax:

`(integer-real>= i r)`

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer value

Name: `r`
Type: `<real>`
Description: A real value

Result value: `#t` iff `i >= r`

Result type: `<boolean>`

Purity of the procedure: pure

`make-numerical-overflow`

Syntax:

```
(make-numerical-overflow s-procedure)
```

Arguments:

Name: `s-procedure`
Type: `<symbol>`
Description: The name of the procedure from which the exception is raised

Result value: An exception object

Result type: `<object>`

Purity of the procedure: pure

The result is actually of list whose head is the symbol `numerical-overflow` and the tail is an association list with single association of symbol `s-procedure` to the value of `s-procedure`.

`nan`

Syntax:

```
(nan)
```

No arguments.

Result value: The exceptional floating point value NaN (not a number)

Result type: <real>

Purity of the procedure: pure

nan?

Syntax:

```
(nan? r)
```

Arguments:

Name: r

Type: <real>

Description: A real number

Result value: Returns #t iff r is a NaN value

Result type: <boolean>

Purity of the procedure: pure

neg-inf

Syntax:

```
(neg-inf)
```

No arguments.

Result value: The exceptional floating point value -inf (negative infinity)

Result type: <real>

Purity of the procedure: pure

quotient

Syntax:

```
(quotient int1 int2)
```

Arguments:

Name: `int1`
Type: `<integer>`
Description: An integer value

Name: `int2`
Type: `<integer>`
Description: An integer value

Result value: The quotient of the arguments

Result type: `<integer>`

Purity of the procedure: pure

If the second argument is 0 raise exception `numerical-overflow`. Note that this procedure always returns an integer.

r-abs

Syntax:

`(r-abs r)`

Arguments:

Name: `r`
Type: `<real>`
Description: A real number

Result value: Absolute value of the argument

Result type: `<real>`

Purity of the procedure: pure

r-ceiling

Syntax:

`(r-ceiling r)`

Arguments:

Name: `r`

Type: `<real>`
Description: A real number

Result value: Rounded value
Result type: `<real>`

Purity of the procedure: pure

This procedure rounds a real number towards infinity and returns a real number.

r-floor

Syntax:

```
(r-floor r)
```

Arguments:

Name: `r`
Type: `<real>`
Description: A real number

Result value: Rounded value
Result type: `<real>`

Purity of the procedure: pure

This procedure rounds a real number towards minus infinity and returns a real number.

r-int-expt

Syntax:

```
(r-int-expt r-base i-expt)
```

Arguments:

Name: `r-base`
Type: `<real>`
Description: A real number

Name: `i-expt`
Type: `<integer>`

Description: An integer number

Result value: `r-base` raised to the power `i-expt`

Result type: `<real>`

Purity of the procedure: pure

`r-neg`

Syntax:

`(r-neg r)`

Arguments:

Name: `r`

Type: `<real>`

Description: A real number

Result value: The opposite number of the argument

Result type: `<real>`

Purity of the procedure: pure

`r-nonneg-int-expt`

Syntax:

`(r-nonneg-int-expt r-base i-expt)`

Arguments:

Name: `r-base`

Type: `<real>`

Description: A real number

Name: `i-expt`

Type: `<integer>`

Description: A nonnegative integer number

Result value: `r-base` raised to the power `i-expt`

Result type: `<real>`

Purity of the procedure: pure

r-round

Syntax:

(r-round r)

Arguments:

Name: r
Type: <real>
Description: A real number

Result value: Rounded value

Result type: <real>

Purity of the procedure: pure

This procedure rounds a real number and return a real number.

r-sign

Syntax:

(r-sign r)

Arguments:

Name: r
Type: <real>
Description: A real number

Result value: Return 0 if $r = 0.0$, 1 if $r > 0.0$, and -1 if $r < 0.0$

Result type: <integer>

Purity of the procedure: pure

Return 0 for the exceptional value NaN.

r-square

Syntax:

`(r-square r)`

Arguments:

Name: `r`
Type: `<real>`
Description: A real number

Result value: Square of the argument

Result type: `<real>`

Purity of the procedure: pure

`r-truncate`

Syntax:

`(r-truncate r)`

Arguments:

Name: `r`
Type: `<real>`
Description: A real number

Result value: Rounded value

Result type: `<real>`

Purity of the procedure: pure

This procedure rounds a real number towards zero and returns a real number.

`raise-numerical-overflow`

Syntax:

`(raise-numerical-overflow s-procedure)`

Arguments:

Name: `s-procedure`
Type: `<symbol>`
Description: The name of the procedure from which the exception is raised

No result value.

Purity of the procedure: pure

This procedure raises a numerical overflow exception and the procedure never returns.

real+

Syntax:

```
(real+ real1 real2)
```

Arguments:

Name: `real1`
Type: `<real>`
Description: A real value

Name: `real2`
Type: `<real>`
Description: A real value

Result value: The sum of the arguments

Result type: `<real>`

Purity of the procedure: pure

real-

Syntax:

```
(real- real1 real2)
```

Arguments:

Name: `real1`
Type: `<real>`
Description: A real value

Name: `real2`
Type: `<real>`
Description: A real value

Result value: The difference of the arguments

Result type: <real>

Purity of the procedure: pure

real*

Syntax:

(real* real1 real2)

Arguments:

Name: real1

Type: <real>

Description: A real value

Name: real2

Type: <real>

Description: A real value

Result value: The product of the arguments

Result type: <real>

Purity of the procedure: pure

real/

Syntax:

(real/ real1 real2)

Arguments:

Name: real1

Type: <real>

Description: A real value

Name: real2

Type: <real>

Description: A real value

Result value: The quotient of the arguments

Result type: <real>

Purity of the procedure: pure

real<

Syntax:

(real< real1 real2)

Arguments:

Name: real1
Type: <real>
Description: A real value

Name: real2
Type: <real>
Description: A real value

Result value: #t iff real1 < real2

Result type: <boolean>

Purity of the procedure: pure

real>

Syntax:

(real> real1 real2)

Arguments:

Name: real1
Type: <real>
Description: A real value

Name: real2
Type: <real>
Description: A real value

Result value: #t iff real1 > real2

Result type: <boolean>

Purity of the procedure: pure

real<=

Syntax:

(real<= real1 real2)

Arguments:

Name: `real1`
Type: `<real>`
Description: A real value

Name: `real2`
Type: `<real>`
Description: A real value

Result value: `#t` iff `real1 ≤ real2`

Result type: `<boolean>`

Purity of the procedure: pure

real>=

Syntax:

(real>= real1 real2)

Arguments:

Name: `real1`
Type: `<real>`
Description: A real value

Name: `real2`
Type: `<real>`
Description: A real value

Result value: `#t` iff `real1 ≥ real2`

Result type: `<boolean>`

Purity of the procedure: pure

real->integer

Syntax:

```
(real->integer r)
```

Arguments:

Name: r
Type: <real>
Description: An integer value of type <real>

Result value: The real value converted to an integer value of type <integer>

Result type: <integer>

Purity of the procedure: pure

If *r* is not an integer value (xxx.0) an exception is raised.

real-integer+

Syntax:

```
(real-integer+ r i)
```

Arguments:

Name: r
Type: <real>
Description: A real value

Name: i
Type: <integer>
Description: An integer value

Result value: The sum of the arguments

Result type: <real>

Purity of the procedure: pure

real-integer-

Syntax:

```
(real-integer- r i)
```

Arguments:

Name: r
Type: <real>
Description: A real value

Name: i
Type: <integer>
Description: An integer value

Result value: The difference of the arguments

Result type: <real>

Purity of the procedure: pure

real-integer*

Syntax:

```
(real-integer* r i)
```

Arguments:

Name: r
Type: <real>
Description: A real value

Name: i
Type: <integer>
Description: An integer value

Result value: The product of the arguments

Result type: <real>

Purity of the procedure: pure

real-integer/

Syntax:

(real-integer/ r i)

Arguments:

Name: r
 Type: <real>
 Description: A real value

Name: i
 Type: <integer>
 Description: An integer value

Result value: The quotient of the arguments

Result type: <real>

Purity of the procedure: pure

real-integer<

Syntax:

(real-integer< r i)

Arguments:

Name: r
 Type: <real>
 Description: A real value

Name: i
 Type: <integer>
 Description: An integer value

Result value: #t iff $r < i$

Result type: <boolean>

Purity of the procedure: pure

real-integer<=

Syntax:

`(real-integer<= r i)`

Arguments:

Name: `r`
Type: `<real>`
Description: A real value

Name: `i`
Type: `<integer>`
Description: An integer value

Result value: `#t` iff `r <= i`

Result type: `<boolean>`

Purity of the procedure: pure

`real-integer>`

Syntax:

`(real-integer> r i)`

Arguments:

Name: `r`
Type: `<real>`
Description: A real value

Name: `i`
Type: `<integer>`
Description: An integer value

Result value: `#t` iff `r > i`

Result type: `<boolean>`

Purity of the procedure: pure

`real-integer>=`

Syntax:

`(real-integer>= r i)`

Arguments:

Name: `r`
Type: `<real>`
Description: A real value

Name: `i`
Type: `<integer>`
Description: An integer value

Result value: `#t` iff `r >= i`

Result type: `<boolean>`

Purity of the procedure: pure

`remainder`

Syntax:

```
(remainder dividend divisor)
```

Arguments:

Name: `dividend`
Type: `<integer>`
Description: The dividend

Name: `divisor`
Type: `<integer>`
Description: The divisor

Result value: The remainder obtained by dividing the dividend with the divisor

Result type: `<integer>`

Purity of the procedure: pure

The semantics of `remainder` is the same as the semantics of procedure `remainder` in Scheme (R6RS).

`round`

Syntax:

```
(round r)
```

Arguments:

Name: `r`
 Type: `<real>`
 Description: A real number

Result value: Rounded value

Result type: `<integer>`

Purity of the procedure: pure

This procedure rounds a real number and returns an integer.

truncate

Syntax:

`(truncate r)`

Arguments:

Name: `r`
 Type: `<real>`
 Description: A real number

Result value: Rounded value

Result type: `<integer>`

Purity of the procedure: pure

This procedure rounds a real number towards zero.

3.9.2 Methods

`equal?: (<object> <object>) → <boolean> pure = equal-values?`
`equal?: (<boolean> <boolean>) → <boolean> pure = boolean=?`
`equal?: (<integer> <integer>) → <boolean> pure = integer=?`
`equal?: (<real> <real>) → <boolean> pure = real=?`
`equal?: (<symbol> <symbol>) → <boolean> pure = symbol=?`
`equal?: (<string> <string>) → <boolean> pure = string=?`
`equal?: (<character> <character>) → <boolean> pure = character=?`

`equal?: (<integer> <real>) → <boolean> pure = integer-real=?`
`equal?: (<real> <integer>) → <boolean> pure = real-integer=?`

`+: (<integer> <integer>) → <integer> pure = integer+`
`+: (<integer> <real>) → <real> pure = integer-real+`

```

+: (<real> <integer>) → <real> pure = real-integer+
+: (<real> <real>) → <real> pure = real+

-: (<integer> <integer>) → <integer> pure = integer-
-: (<integer> <real>) → <real> pure = integer-real-
-: (<real> <integer>) → <real> pure = real-integer-
-: (<real> <real>) → <real> pure = real-

*: (<integer> <integer>) → <integer> pure = integer*
*: (<integer> <real>) → <real> pure = integer-real*
*: (<real> <integer>) → <real> pure = real-integer*
*: (<real> <real>) → <real> pure = real*

/: (<integer> <real>) → <real> pure = integer-real/
/: (<real> <integer>) → <real> pure = real-integer/
/: (<real> <real>) → <real> pure = real/

```

Note that division / between two integers is not defined in the core module as its result is a rational number.

```

<: (<integer> <integer>) → <boolean> pure = integer<
<: (<integer> <real>) → <boolean> pure = integer-real<
<: (<real> <integer>) → <boolean> pure = real-integer<
<: (<real> <real>) → <boolean> pure = real<

<=: (<integer> <integer>) → <boolean> pure = integer<=
<=: (<integer> <real>) → <boolean> pure = integer-real<=
<=: (<real> <integer>) → <boolean> pure = real-integer<=
<=: (<real> <real>) → <boolean> pure = real<=

>: (<integer> <integer>) → <boolean> pure = integer>
>: (<integer> <real>) → <boolean> pure = integer-real>
>: (<real> <integer>) → <boolean> pure = real-integer>
>: (<real> <real>) → <boolean> pure = real>

>=: (<integer> <integer>) → <boolean> pure = integer>=
>=: (<integer> <real>) → <boolean> pure = integer-real>=
>=: (<real> <integer>) → <boolean> pure = real-integer>=
>=: (<real> <real>) → <boolean> pure = real>=

-: (<integer>) → <integer> pure = i-neg
-: (<real>) → <real> pure = r-neg
abs: (<integer>) → <integer> pure = i-abs
abs: (<real>) → <real> pure = r-abs
square: (<integer>) → <integer> pure = i-square
square: (<real>) → <real> pure = r-square
sign: (<integer>) → <integer> pure = i-sign
sign: (<real>) → <integer> pure = r-sign

```


Chapter 4

Module (standard-library core-forms)

4.1 Macros

with-syntax

See [2].

syntax-rules

See [2].

identifier-syntax

See [2].

quasiquote

See [2].

quasisyntax

See [2].

cond*Syntax:*

$$(\mathbf{cond} \ [clause\text{-}list] \ [else\text{-}clause] \)$$

$$clause\text{-}list ::= clause_1, \dots, clause_n$$

$$clause_k ::= (condition_k \ expr_{k,1}, \dots, expr_{k,m(k)} \)$$

$$else\text{-}clause ::= (\mathbf{else} \ else\text{-}expr_1, \dots, else\text{-}expr_p \)$$

Each condition must have type `<boolean>`. The type of each $clause_k$ is the type of $expr_{k,m(k)}$ (the last expression in the clause). If $else\text{-}clause$ is present its type is the type of $else\text{-}expr_p$ (the last expression in the else clause). If $else\text{-}expression$ is defined the type of the **cond** expression is the union of the types of each clause and the type of the $else\text{-}clause$. Otherwise the type of the **cond** expression is `<none>`.

Each $condition_k$ is evaluated in order until some of them returns `#t`. When some $condition_k$ returns `#t` the expressions $expr_{k,1}, \dots, expr_{k,m(k)}$ are evaluated in order. If the result type of the **cond** expression is not `<none>` the value of the last expression $expr_{k,m(k)}$ is returned as the value of the **cond** expression. If none of the conditions return `#t` and $else\text{-}clause$ is present the expressions $else\text{-}expr_1, \dots, else\text{-}expr_p$ are evaluated in order. If the result type of the **cond** expression is not `<none>` the value of the last expression $else\text{-}expr_p$ is returned as the value of the **cond** expression.

and*Syntax:*

$$(\mathbf{and} \ arg_1 \ \dots \ arg_n \)$$

The type of each arg_k has to be `<boolean>`. The arguments are evaluated in order until some of the arguments returns `#f`. If all of the arguments return `#t` the result of the **and** expression is `#t`. Otherwise the result value is `#f`. Note that all of the arguments are not necessarily evaluated at all.

or*Syntax:*

$$(\mathbf{or} \ arg_1 \ \dots \ arg_n \)$$

The type of each arg_k has to be `<boolean>`. The arguments are evaluated in order until some of the arguments returns `#t`. If all of the arguments return `#f` the result of the `or` expression is `#f`. Otherwise the result value is `#t`. Note that all of the arguments are not necessarily evaluated at all.

cond-object

Syntax:

`(cond-object [clause-list] [else-clause])`

$clause\text{-}list ::= clause_1, \dots, clause_n$

$clause_k ::= (condition_k\ expr_{k,1}, \dots, expr_{k,m(k)}) | (condition_k => handler_k)$

$else\text{-}clause ::= (else\ else\text{-}expr_1, \dots, else\text{-}expr_p)$

This form works as `cond` except all nonfalse values are implemented as true in the conditions. When a clause is of type $(condition_k => handler_k)$ expression $handler_k$ has to be a procedure accepting a single argument. When this kind of clause is encountered the $condition_k$ is evaluated and if its result is not false it is passed to the procedure $handler_k$ whose result is returned.

and-object

Syntax:

`(and-object expression ...)`

Start evaluating the argument expressions from the left. If any argument returns `#f` stop the evaluation and return `#f`. Otherwise return the value of the last expression.

or-object

Syntax:

`(or-object expression ...)`

Start evaluating the argument expressions from the left. If any argument returns a nonfalse value stop the evaluation and return this value. Otherwise return `#f`.

let*

Syntax:

(let* (*var-spec*₁ ... *var-spec*_{*n*}) *let-body-expressions*)

*var-spec*_{*k*} ::= (*var-name*_{*k*} [*var-type*_{*k*}] *value*_{*k*})

*var-name*_{*k*} ::= identifier

let-body-expressions ::= expression ...

The **let*** form is similar to **let** except that the expressions *value*_{*k*} are evaluated in order and each expression may use the variables defined before it.

let*-mutable

Syntax:

(let*-mutable (*var-spec*₁ ... *var-spec*_{*n*}) *let-body-expressions*)

*var-spec*_{*k*} ::= (*var-name*_{*k*} *var-type*_{*k*} *value*_{*k*})

*var-name*_{*k*} ::= identifier

let-body-expressions ::= expression ...

The **let*-mutable** form is similar to **let-mutable** except that the expressions *value*_{*k*} are evaluated in order and each expression may use the variables defined before it.

let*-volatile

Syntax:

(let*-volatile (*var-spec*₁ ... *var-spec*_{*n*}) *let-body-expressions*)

*var-spec*_{*k*} ::= (*var-name*_{*k*} *var-type*_{*k*} *value*_{*k*})

*var-name*_{*k*} ::= identifier

let-body-expressions ::= expression ...

The **let*-volatile** form is similar to **let-volatile** except that the expressions *value*_{*k*} are evaluated in order and each expression may use the variables defined before it.

case*Syntax:*

```
(case value [clause-list] [else-clause] )
```

```
clause-list ::= clause1, ..., clausen
```

```
clausek ::= ((keyk,1 ...keyk,p(k)) exprk,1, ..., exprk,m(k))
```

```
else-clause ::= (else else-expr1, ..., else-exprq)
```

The clauses are processed in order. If *value* is equal to some of the keys for clause *k* in the sense of the equality predicate `equal?` processing the clauses is stopped and expressions *expr*_{*k,j*} are evaluated in order and the value of the last of these expressions is returned as the value of the **case** expression. If none of the clauses match and the else clause is present the expressions *else-expr*_{*j*} are evaluated in order and the value of the last of these expressions is returned. If none of the clauses match and the else clause is not present the **case** expression returns nothing.

do*Syntax:*

```
(do (var-spec1 ... var-specn)
  (condition [result-expression] )
  body-expression1 ...body-expressionn )
```

```
var-speck ::= (var-namek var-typek init-valuek update-exprk )
```

```
var-namek ::= identifier
```

The type of *condition* has to be `<boolean>`. At the beginning of each iteration *condition* is evaluated. If it returns `#t` the iteration is stopped and the value of *result-expression* is returned as the result of the **do** expression. Otherwise the body expressions are evaluated in order, variables *var-name*_{*k*} are assigned new values obtained by evaluating each *update-expr*_{*k*} in order, and the next iteration is started from the beginning. If *result-type* is not specified the type of the **do** expression is `<none>`. Expression

```
(do ((var-name1 var-type1 init-value1 update-expr1) ...
      (var-namem var-typem init-valuem update-exprm ))
  (condition [result-expression] )
  body-expression1 ...body-expressionn )
```

is equivalent to

```

(let-mutable ((var-name1 var-type1 init-value1 )...
              (var-namem var-typem init-valuem ))
  (until (condition [result-expression] )
           body-expression1 ...
           body-expressionn
           (set! var-name1 update-expr1 )...
           (set! var-namem update-exprm )))

```

\$let*
\$letrec
\$letrec*

Syntax:

```

({$let* | $letrec | $letrec* } (var-spec1 ... var-specn ) let-body-expressions )

```

*var-spec*_{*k*} ::= (*var-name*_{*k*} *value*_{*k*})

*var-name*_{*k*} ::= identifier

let-body-expressions ::= expression ...

These forms work like the corresponding Scheme forms without the leading '\$', see [2]. These forms may only be used in macro transformers.

\$and

Syntax:

```

($and expression ... )

```

This form works like Theme-D **and-object** and Scheme form **and**. This form may only be used in macro transformers.

\$or

Syntax:

```

($or expression ... )

```

This form works like Theme-D **or-object** and Scheme form **or**. This form may only be used in macro transformers.

define-normal-goops-class

Syntax:

```
(define-normal-goops-class name target-name superclass inheritable? im-
mutable? equal-by-value? )
name ::=identifier
target-name ::=identifier
inheritable? ::=boolean
immutable? ::=boolean
equal-by-value? ::=boolean
```

This keyword defines a GOOPS class with the default equivalence predicates (Scheme `eqv?` for `equal?` and `equal-contents?` and Scheme `eq?` for `equal-objects?`) and no zero object.

define-param-method

Syntax:

```
(define-param-method method-name (type1 ... typen) (argument-list result-
type attribute-list) body-expr1, ..., body-exprn )
```

```
method-name ::=identifier
argument-list ::=([arg1 ... argn])
argk ::=(arg-namek arg-typek)
arg-namek ::=identifier
attribute-list ::=(attribute ...) | attribute
attribute ::=pure | nonpure | force-pure
           | always-returns | may-return | never-returns | static
```

The **define-param-method** defines a parametrized method. Note that the argument list may be (). Expressions *arg-type_k* and *result-type* have to be static type expressions. It is an error if the result type is not `<none>` and the type of the last body expression is not a subtype of *result-type*. If *result-type* is not `<none>` the result value of the procedure is the value of the last body expression.

define-param-proc

Syntax:

(define-param-proc *procedure-name* (*type*₁ ... *type*_{*n*}) (*argument-list* *result-type* *attribute-list*) *body-expr*₁, ..., *body-expr*_{*n*})

procedure-name ::= identifier

*type*_{*k*} ::= identifier

argument-list ::= ([*arg*₁ ... *arg*_{*n*}])

*arg*_{*k*} ::= (*arg-name*_{*k*} *arg-type*_{*k*})

*arg-name*_{*k*} ::= identifier

attribute-list ::= (*attribute* ...) | *attribute*

attribute ::= pure | nonpure | force-pure

| always-returns | may-return | never-returns | static

Keyword **define-param-proc** defines constant *procedure-name* with a parametrized procedure value. Note that the argument list may be (). Expressions *arg-type*_{*k*} and *result-type* have to be static type expressions. It is an error if the type of the last body expression is not a subtype of *result-type*. If *result-type* is not <none> the result value of the procedure is the value of the last body expression.

define-simple-method

Syntax:

(define-simple-method *method-name* (*argument-list* *result-type* *attribute-list*) *body-expr*₁, ..., *body-expr*_{*n*})

method-name ::= identifier

argument-list ::= ([*arg*₁ ... *arg*_{*n*}])

*arg*_{*k*} ::= (*arg-name*_{*k*} *arg-type*_{*k*})

*arg-name*_{*k*} ::= identifier

attribute-list ::= (*attribute* ...) | *attribute*

attribute ::= pure | nonpure | force-pure

| always-returns | may-return | never-returns | static

Keyword **define-simple-method** defines a simple method. Note that the argument list may be (). Expressions *arg-type*_{*k*} and *result-type* have to be static type expressions. It is an error if the result type is not <none> and the type of the last body expression is not a subtype of *result-type*. If *result-type* is not <none> the result value of the procedure is the value of the last body expression.

define-simple-proc

Syntax:


```
(define-simple-proc procedure-name (argument-list result-type attribute-list)
  body-expr1, ..., body-exprn)
```

```
procedure-name ::= identifier
argument-list ::= ([arg1 ... argn] )
argk ::= (arg-namek arg-typek)
arg-namek ::= identifier
attribute-list ::= (attribute ... ) | attribute
attribute ::= pure | nonpure | force-pure
              | always-returns | may-return | never-returns | static
```

Keyword **define-simple-proc** defines constant *procedure-name* with a simple procedure value. Note that the argument list may be (). Expressions *arg-type*_{*k*} and *result-type* have to be static type expressions. It is an error if the result type is not <none> and the type of the last body expression is not a subtype of *result-type*. If *result-type* is not <none> the result value of the procedure is the value of the last body expression.

guard

Syntax:

```
(guard (exception-variable clause1 ... clausen else-clause)
  body-expr1 ... body-exprn)
```

The syntax of *clause*_{*k*} and *else-clause* is similar to the same syntax elements in **cond** form, see section 4.1. The semantics of **guard** is similar to the semantics in Scheme.

make

Syntax:

```
(make class field-value1 ... field-valuen)
```

Keyword **make** creates an instance of *class* calling the constructor of *class* and passing the arguments *field-value*_{*k*}. Expression *class* has to be a static type expression and its value has to be a class.

Chapter 5

Module (standard-library bitwise-arithmetic)

5.1 Simple Procedures

bitwise-not

Syntax:

```
(bitwise-not i)
```

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer number

Result value: The ones-complement of the argument

Result type: `<integer>`

Purity of the procedure: pure

bitwise-and

Syntax:

```
(bitwise-and i1 i2)
```

Arguments:

Name: `i1`
Type: `<integer>`
Description: An integer number

Name: `i2`
Type: `<integer>`
Description: An integer number

Result value: The bitwise AND between the arguments

Result type: `<integer>`

Purity of the procedure: pure

`bitwise-ior`

Syntax:

```
(bitwise-ior i1 i2)
```

Arguments:

Name: `i1`
Type: `<integer>`
Description: An integer number

Name: `i2`
Type: `<integer>`
Description: An integer number

Result value: The bitwise OR between the arguments

Result type: `<integer>`

Purity of the procedure: pure

`bitwise-xor`

Syntax:

```
(bitwise-xor i1 i2)
```

Arguments:

Name: `i1`
Type: `<integer>`
Description: An integer number

Name: `i2`
Type: `<integer>`
Description: An integer number

Result value: The bitwise XOR between the arguments

Result type: `<integer>`

Purity of the procedure: pure

`bitwise-arithmetic-shift`

Syntax:

```
(bitwise-arithmetic-shift i i-shift)
```

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer number

Name: `i-shift`
Type: `<integer>`
Description: The number of bits to be shifted (maybe negative)

Result value: Value of `i` with bits shifted by `i-shift` positions

Result type: `<integer>`

Purity of the procedure: pure

Positive values of `i-shift` mean shifting bits left and negative values shifting right. Name `ash` is an alias for `bitwise-arithmetic-shift`.

`bitwise-arithmetic-shift-right`

Syntax:

```
(bitwise-arithmetic-shift-right i i-shift)
```

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer number

Name: `i-shift`
Type: `<integer>`
Description: The number of bits to be shifted (maybe negative)

Result value: Value of `i` with bits shifted right by `i-shift` positions
Result type: `<integer>`

Purity of the procedure: pure

Negative values of `i-shift` shift bit to the left.

`bitwise-arithmetic-shift-left`

Syntax:

```
(bitwise-arithmetic-shift-left i i-shift)
```

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer number

Name: `i-shift`
Type: `<integer>`
Description: The number of bits to be shifted (maybe negative)

Result value: Value of `i` with bits shifted left by `i-shift` positions
Result type: `<integer>`

Purity of the procedure: pure

Negative values of `i-shift` shift bit to the right.

Chapter 6

Module (standard-library promise)

This module implements delayed evaluation with the promise objects. The promises resemble Scheme promises, see [2].

6.1 Data Types

Data type name: `:promise`

Type: `:procedure`

Number of type parameters: 1

Description: A promise object

Data type name: `:nonpure-promise`

Type: `:procedure`

Number of type parameters: 1

Description: A promise object that can have side effects

6.2 Macros

delay

Syntax:

`(delay expression)`

This macro creates a promise that delays the evaluation of the given expression. This is a frontend to the procedure `make-promise`. The argument expression has to be pure.

delay-nonpure

Syntax:

(**delay-nonpure** *expression*)

This macro creates a promise that delays the evaluation of the given expression. This is a frontend to the procedure `make-promise`. The argument expression may be nonpure.

6.3 Parametrized Procedures

force

Syntax:

(**force** *promise*)

Type parameters: %type

Arguments:

Name: `promise`
Type: (`:promise` %type)
Description: A promise

Result value: The value of the promise

Result type: %type

Purity of the procedure: pure

This procedure evaluates the promise if it has not already been done and returns the value.

force-nonpure

Syntax:

(**force-nonpure** *promise*)

Type parameters: %type

Arguments:

Name: `promise`
Type: `(:nonpure-promise %type)`
Description: A nonpure promise

Result value: The value of the promise

Result type: `%type`

Purity of the procedure: nonpure

This procedure evaluates the promise if it has not already been done and returns the value.

`make-nonpure-promise`

Syntax:

```
(make-nonpure-promise proc)
```

Type parameters: `%type`

Arguments:

Name: `proc`
Type: `(:procedure () %type nonpure)`
Description: A procedure

Result value: A promise

Result type: `(:nonpure-promise %type)`

Purity of the procedure: pure

This procedure creates a promise that delays the evaluation of the given procedure.

`make-promise`

Syntax:

```
(make-promise proc)
```

Type parameters: `%type`

Arguments:

Name: `proc`
Type: `(:procedure () %type pure)`
Description: A procedure

Result value: A promise
Result type: `(:promise %type)`

Purity of the procedure: pure

This procedure creates a promise that delays the evaluation of the given procedure. The procedure has to be pure.

Chapter 7

Module (standard-library stream)

Streams are kind of abstract sequences. A stream is defined by the following operations:

- *stream-value*: Return the current value of the stream.
- *stream-next*: Read one stream element forward and return the stream with the new element as its current value.
- *stream-empty?*: Return true iff the stream is empty.

See programs `test451.thp`, `test452.thp`, and `test453.thp` in directory `theme-d-code/tests` for examples.

7.1 Data Types

Data type name: `:stream`

Type: `:union`

Number of type parameters: 1

Description: A stream

Data type name: `:nonempty-stream`

Type: `:pair`

Number of type parameters: 1

Description: A nonempty stream

Data type name: `:nonpure-stream`

Type: `:union`

Number of type parameters: 1

Description: A nonpure stream

Data type name: `:nonempty-nonpure-stream`

Type: `:pair`

Number of type parameters: 1

Description: A nonempty nonpure stream

7.2 Simple Procedures

make-input-expr-stream

Syntax:

```
(make-input-expr-stream ip)
```

Arguments:

Name: ip

Type: <input-port>

Description: An input port

Result value: A nonpure stream that reads from the given input port

Result type: (:nonpure-stream <object>)

Purity of the procedure: pure

7.3 Parametrized Procedures

stream-value

Syntax:

```
(stream-value stm)
```

Type parameters: %type

Arguments:

Name: stm

Type: (:stream %type)

Description: A stream

Result value: The current value of the stream

Result type: %type

Purity of the procedure: pure

If the stream `stm` is empty this procedure raises an exception.

`stream-next`

Syntax:

```
(stream-next stm)
```

Type parameters: %type

Arguments:

Name: `stm`
Type: `(:stream %type)`
Description: A stream

Result value: A stream located one step forward from the given stream

Result type: `(:stream %type)`

Purity of the procedure: pure

If the stream `stm` is empty this procedure raises an exception.

`stream-empty?`

Syntax:

```
(stream-empty? stm)
```

Type parameters: %type

Arguments:

Name: `stm`
Type: `(:stream %type)`
Description: A stream

Result value: `#t` iff the stream is empty

Result type: `<boolean>`

Purity of the procedure: pure

stream->list

Syntax:

```
(stream->list stm)
```

Type parameters: %type

Arguments:

Name: **stm**
Type: (:stream %type)
Description: A stream

Result value: A list

Result type: (:uniform-list %type)

Purity of the procedure: pure

This procedure constructs a list by reading the stream until it is empty.

list->stream

Syntax:

```
(list->stream l)
```

Type parameters: %type

Arguments:

Name: **stm**
Type: (:uniform-list %type)
Description: A list

Result value: A stream that processes the given list

Result type: (:stream %type)

Purity of the procedure: pure

nonpure-stream-value

Syntax:

```
(nonpure-stream-value stm)
```

Type parameters: %type

Arguments:

Name: `stm`
Type: `(:nonpure-stream %type)`
Description: A nonpure stream

Result value: The current value of the stream

Result type: %type

Purity of the procedure: pure

If the stream `stm` is empty this procedure raises an exception.

`nonpure-stream-next`

Syntax:

```
(nonpure-stream-next stm)
```

Type parameters: %type

Arguments:

Name: `stm`
Type: `(:nonpure-stream %type)`
Description: A nonpure stream

Result value: A nonpure stream located one step forward from the given nonpure-stream

Result type: `(:nonpure-stream %type)`

Purity of the procedure: nonpure

If the stream `stm` is empty this procedure raises an exception.

`nonpure-stream-empty?`

Syntax:

```
(nonpure-stream-empty? stm)
```

Type parameters: %type

Arguments:

Name: `stm`
Type: `(:nonpure-stream %type)`
Description: A nonpure stream

Result value: `#t` iff the stream is empty

Result type: `<boolean>`

Purity of the procedure: pure

`nonpure-stream->list`

Syntax:

`(nonpure-stream->list stm)`

Type parameters: %type

Arguments:

Name: `stm`
Type: `(:nonpure-stream %type)`
Description: A nonpure stream

Result value: A list

Result type: `(:uniform-list %type)`

Purity of the procedure: nonpure

This procedure constructs a list by reading the stream until it is empty.

`stream-map`

Syntax:

`(stream-map proc stm)`

Type parameters: %type1, %type2

Arguments:

Name: `proc`
 Type: `(:procedure (%type1) %type2 pure)`
 Description: The procedure to be applied

Name: `stm`
 Type: `(:stream %type1)`
 Description: The source stream

Result value: The target stream
Result type: `(:stream %type2)`

Purity of the procedure: pure

This procedure applies the argument procedure to the source stream elements with delayed evaluation. Another stream is returned.

`stream-map-nonpure`

Syntax:

```
(stream-map-nonpure proc stm)
```

Type parameters: `%type1`, `%type2`

Arguments:

Name: `proc`
 Type: `(:procedure (%type1) %type2 nonpure)`
 Description: The procedure to be applied

Name: `stm`
 Type: `(:stream %type1)`
 Description: The source stream

Result value: The target stream
Result type: `(:nonpure-stream %type2)`

Purity of the procedure: nonpure

This procedure applies the argument procedure to the source stream elements with delayed evaluation. Another stream is returned. The applied procedure may have side effects and the result is a nonpure stream.

`stream-for-each`

Syntax:

```
(stream-for-each proc stm)
```

Type parameters: %type1

Arguments:

Name: `proc`
 Type: `(:procedure (%type1) <none> nonpure)`
 Description: The procedure to be applied

Name: `stm`
 Type: `(:stream %type1)`
 Description: A stream

No result value.

Purity of the procedure: nonpure

This procedure applies the argument procedure to the source stream elements. The evaluation is not delayed and no value is returned.

nonpure-stream-map

Syntax:

```
(nonpure-stream-map proc stm)
```

Type parameters: %type1, %type2

Arguments:

Name: `proc`
 Type: `(:procedure (%type1) %type2 nonpure)`
 Description: The procedure to be applied

Name: `stm`
 Type: `(:nonpure-stream %type1)`
 Description: The source stream

Result value: The target stream

Result type: `(:nonpure-stream %type2)`

Purity of the procedure: nonpure

This procedure applies the argument procedure to the source nonpure stream elements with delayed evaluation. Another stream is returned. The applied procedure may have side effects and the result is a nonpure stream.

nonpure-stream-for-each

Syntax:

```
(nonpure-stream-for-each proc stm)
```

Type parameters: %type1

Arguments:

Name: `proc`
Type: `(:procedure (%type1) <none> nonpure)`
Description: The procedure to be applied

Name: `stm`
Type: `(:nonpure-stream %type1)`
Description: A nonpure stream

No result value.

Purity of the procedure: nonpure

This procedure applies the argument procedure to the source nonpure stream elements. The evaluation is not delayed and no value is returned.

Chapter 8

Module (standard-library iterator)

This module implements purely functional iterators, see [1].

8.1 Data Types

Data type name: `:iterator`

Type: `<param-logical-type>`

Number of type parameters: 1

Definition: `(:param-proc (%target) ((:consumer %source %target)) %target pure)`

Description: An iterator

Data type name: `:iterator-inst`

Type: `<param-logical-type>`

Number of type parameters: 2

Definition: `(:procedure ((:consumer %source %target)) %target pure)`

Description: An instance of an iterator for which the target type or the iteration is fixed

Data type name: `:consumer`

Type: `<param-logical-type>`

Number of type parameters: 2

Definition: `(:procedure ((:maybe %source) <boolean> (:maybe (:iterator-inst %source %target)))) %target pure)`

Description: A procedure that “consumes” values yielded by an iterator

8.2 Parametrized Procedures

`end-iter`

Syntax:

```
(end-iter consumer)
```

Type parameters: %source, %target

Arguments:

```
Name: consumer
Type: (:consumer %source %target)
Description: A consumer procedure
```

Result value: Target object

Result type: %target

Purity of the procedure: pure

This procedure is used when the iterator reaches its end.

gen-list

Syntax:

```
(gen-list l consumer iterator-inst)
```

Type parameters: %source, %target

Arguments:

```
Name: l
Type: (:uniform-list %source)
Description: A list for which to create an iterator
```

```
Name: consumer
Type: (:consumer %source %target)
Description: A consumer procedure
```

```
Name: iterator-inst
Type: (:iterator-inst %source %target)
Description: An iterator instance
```

Result value: Target object

Result type: %target

Purity of the procedure: pure

This procedure is used internally to create a list iterator.

get-list-iterator

Syntax:

```
(get-list-iterator l)
```

Type parameters: %source

Arguments:

Name: l
Type: (:uniform-list %source)
Description: A list for which to create an iterator

Result value: An iterator for the given list

Result type: (:iterator %source)

Purity of the procedure: pure

This procedure is used to create a list iterator.

gen-mutable-vector

Syntax:

```
(gen-mutable-vector v consumer iterator-inst)
```

Type parameters: %source, %target

Arguments:

Name: v
Type: (:mutable-vector %source)
Description: A mutable vector for which to create an iterator

Name: consumer
Type: (:consumer %source %target)
Description: A consumer procedure

Name: iterator-inst
Type: (:iterator-inst %source %target)
Description: An iterator instance

Result value: Target object

Result type: %target

Purity of the procedure: pure

This procedure is used internally to create a mutable vector iterator.

get-mutable-vector-iterator

Syntax:

```
(get-mutable-vector-iterator v)
```

Type parameters: %source

Arguments:

Name: v

Type: (:mutable-vector %source)

Description: A mutable vector for which to create an iterator

Result value: An iterator for the given mutable vector

Result type: (:iterator %source)

Purity of the procedure: pure

This procedure is used to create an iterator for a mutable vector.

iter-map1

Syntax:

```
(iter-map1 proc iterator)
```

Type parameters: %source, %component

Arguments:

Name: proc

Type: (:procedure (%source) %component pure)

Description: A procedure to apply to the given iterator

Name: iterator

Type: (:iterator %source)

Description: An iterator to iterate the given procedure

Result value: A list constructed by applying the given procedure to the values yielded by the iterator

Result type: (:uniform-list %component)

Purity of the procedure: pure

This procedure maps the given procedure to each element yielded by the iterator and constructs a list from the result values.

iter-map2

Syntax:

```
(iter-map2 proc iterator1 iterator2)
```

Type parameters: %source1, %source2, %component

Arguments:

Name: `proc`

Type: (:procedure (%source1 %source2) %component pure)

Description: A procedure to apply to the given iterator

Name: `iterator1`

Type: (:iterator %source1)

Description: An iterator to iterate the given procedure

Name: `iterator2`

Type: (:iterator %source2)

Description: Another iterator to iterate the given procedure

Result value: A list constructed by applying the given procedure to the values yielded by the iterators

Result type: (:uniform-list %component)

Purity of the procedure: pure

This procedure maps pairwise the given procedure to all the elements yielded by the iterators and constructs a list from the result values.

iter-every1

Syntax:

```
(iter-every1 proc iterator)
```

Type parameters: %source

Arguments:

Name: `proc`
Type: `(:procedure (%source) <boolean> pure)`
Description: A procedure to apply to the given iterator

Name: `iterator`
Type: `(:iterator %source)`
Description: An iterator to iterate the given procedure

Result value: #t iff the procedure is returns true for all iterated values

Result type: <boolean>

Purity of the procedure: pure

This procedure maps the given procedure to each element yielded by the iterator and returns #t iff all the results are #t. If some application returns #f the application is terminated and #f returned.

iter-every2

Syntax:

```
(iter-every2 proc iterator1 iterator2)
```

Type parameters: %source1, %source2

Arguments:

Name: `proc`
Type: `(:procedure (%source1 %source2) <boolean> pure)`
Description: A procedure to apply to the given iterator

Name: `iterator1`
Type: `(:iterator %source1)`
Description: An iterator to iterate the given procedure

Name: `iterator2`
Type: `(:iterator %source2)`
Description: Another iterator to iterate the given procedure

Result value: #t iff the procedure is returns true for all iterated values

Result type: <boolean>

Purity of the procedure: pure

This procedure maps pairwise the given procedure to all the elements yielded by the iterators and returns **#t** iff all the results are **#t**. If some application returns **#f** the application is terminated and **#f** returned.

Chapter 9

Module (standard-library nonpure-iterator)

This module `nonpure` implements nonpure iterators analogous to the purely functional ones presented in the previous section. Nonpure iterators are needed in following cases:

- The operation done to the values yielded by iterators has side effects, e.g. printing.
- The generation of values for an iterator has side effects, e.g. reading values from a file.

9.1 Data Types

Data type name: `:nonpure-iterator`

Type: `<param-logical-type>`

Number of type parameters: 1

Definition: `(:param-proc (%target) ((:nonpure-consumer %source %target)) %target nonpure)`

Description: An iterator

Data type name: `:nonpure-iterator-inst`

Type: `<param-logical-type>`

Number of type parameters: 2

Definition: `(:procedure ((:nonpure-consumer %source %target)) %target nonpure)`

Description: An instance of an iterator for which the target type or the iteration is fixed

Data type name: `:nonpure-consumer`

Type: `<param-logical-type>`

Number of type parameters: 2

Definition: `(:procedure ((:maybe %source) <boolean> (:maybe (:nonpure-iterator-inst %source %target)))) %target nonpure)`

Description: A procedure that “consumes” values yielded by an iterator

9.2 Parametrized Procedures

nonpure-end-iter

Syntax:

```
(nonpure-end-iter consumer)
```

Type parameters: %source, %target

Arguments:

```
Name: consumer
Type: (:nonpure-consumer %source %target)
Description: A consumer procedure
```

Result value: Target object

Result type: %target

Purity of the procedure: nonpure

This procedure is used when the iterator reaches its end.

gen-list-nonpure

Syntax:

```
(gen-list-nonpure l consumer iterator-inst)
```

Type parameters: %source, %target

Arguments:

```
Name: l
Type: (:uniform-list %source)
Description: A list for which to create an iterator
```

```
Name: consumer
Type: (:nonpure-consumer %source %target)
Description: A consumer procedure
```

```
Name: iterator-inst
```

Type: (:nonpure-iterator-inst %source %target)
Description: An iterator instance

Result value: Target object
Result type: %target

Purity of the procedure: nonpure

This procedure is used internally to create a list iterator.

get-list-nonpure-iterator

Syntax:

```
(get-list-nonpure-iterator l)
```

Type parameters: %source

Arguments:

Name: l
Type: (:uniform-list %source)
Description: A list for which to create an iterator

Result value: An iterator for the given list
Result type: (:nonpure-iterator %source)

Purity of the procedure: nonpure

This procedure is used to create a list iterator.

gen-mutable-vector-nonpure

Syntax:

```
(gen-mutable-vector-nonpure v consumer iterator-inst)
```

Type parameters: %source, %target

Arguments:

Name: v
Type: (:mutable-vector %source)
Description: A mutable vector for which to create an iterator

Name: `consumer`
 Type: `(:nonpure-consumer %source %target)`
 Description: A consumer procedure

Name: `iterator-inst`
 Type: `(:nonpure-iterator-inst %source %target)`
 Description: An iterator instance

Result value: Target object
Result type: `%target`

Purity of the procedure: nonpure

This procedure is used internally to create a mutable vector iterator.

`get-mutable-vector-nonpure-iterator`

Syntax:

```
(get-mutable-vector-nonpure-iterator v)
```

Type parameters: `%source`

Arguments:

Name: `v`
 Type: `(:mutable-vector %source)`
 Description: A mutable vector for which to create an iterator

Result value: An iterator for the given mutable vector
Result type: `(:nonpure-iterator %source)`

Purity of the procedure: nonpure

This procedure is used to create an iterator for a mutable vector.

`nonpure-iter-map1`

Syntax:

```
(nonpure-iter-map1 proc iterator)
```

Type parameters: `%source`, `%component`

Arguments:

Name: `proc`
 Type: `(:procedure (%source) %component nonpure)`
 Description: A procedure to apply to the given iterator

Name: `iterator`
 Type: `(:nonpure-iterator %source)`
 Description: An iterator to iterate the given procedure

Result value: A list constructed by applying the given procedure to the values yielded by the iterator

Result type: `(:uniform-list %component)`

Purity of the procedure: nonpure

This procedure maps the given procedure to each element yielded by the iterator and constructs a list from the result values.

nonpure-iter-map2

Syntax:

```
(nonpure-iter-map2 proc iterator1 iterator2)
```

Type parameters: `%source1`, `%source2`, `%component`

Arguments:

Name: `proc`
 Type: `(:procedure (%source1 %source2) %component nonpure)`
 Description: A procedure to apply to the given iterator

Name: `iterator1`
 Type: `(:nonpure-iterator %source1)`
 Description: An iterator to iterate the given procedure

Name: `iterator2`
 Type: `(:nonpure-iterator %source2)`
 Description: Another iterator to iterate the given procedure

Result value: A list constructed by applying the given procedure to the values yielded by the iterators

Result type: `(:uniform-list %component)`

Purity of the procedure: nonpure

This procedure maps pairwise the given procedure to all the elements yielded

by the iterators and constructs a list from the result values.

nonpure-iter-every1

Syntax:

```
(nonpure-iter-every1 proc iterator)
```

Type parameters: %source

Arguments:

Name: `proc`
 Type: `(:procedure (%source) <boolean> nonpure)`
 Description: A procedure to apply to the given iterator

Name: `iterator`
 Type: `(:nonpure-iterator %source)`
 Description: An iterator to iterate the given procedure

Result value: #t iff the procedure is returns true for all iterated values

Result type: <boolean>

Purity of the procedure: nonpure

This procedure maps the given procedure to each element yielded by the iterator and returns #t iff all the results are #t. If some application returns #f the application is terminated and #f returned.

nonpure-iter-every2

Syntax:

```
(nonpure-iter-every2 proc iterator1 iterator2)
```

Type parameters: %source1, %source2

Arguments:

Name: `proc`
 Type: `(:procedure (%source1 %source2) <boolean> nonpure)`
 Description: A procedure to apply to the given iterator

Name: `iterator1`
 Type: `(:nonpure-iterator %source1)`

Description: An iterator to iterate the given procedure

Name: `iterator2`

Type: `(:nonpure-iterator %source2)`

Description: Another iterator to iterate the given procedure

Result value: `#t` iff the procedure is returns true for all iterated values

Result type: `<boolean>`

Purity of the procedure: nonpure

This procedure maps pairwise the given procedure to all the elements yielded by the iterators and returns `#t` iff all the results are `#t`. If some application returns `#f` the application is terminated and `#f` returned.

nonpure-iter-for-each1

Syntax:

```
(nonpure-iter-for-each1 proc iterator)
```

Type parameters: `%source`

Arguments:

Name: `proc`

Type: `(:procedure (%source) <none> nonpure)`

Description: A procedure to apply to the given iterator

Name: `iterator`

Type: `(:nonpure-iterator %source)`

Description: An iterator to iterate the given procedure

No result value.

Purity of the procedure: nonpure

This procedure maps the given procedure to each element yielded by the iterator.

nonpure-iter-for-each2

Syntax:

```
(nonpure-iter-for-each2 proc iterator1 iterator2)
```

Type parameters: %source1, %source2

Arguments:

Name: `proc`
 Type: (:procedure (%source1 %source2) <none> nonpure)
 Description: A procedure to apply to the given iterator

Name: `iterator1`
 Type: (:nonpure-iterator %source1)
 Description: An iterator to iterate the given procedure

Name: `iterator2`
 Type: (:nonpure-iterator %source2)
 Description: Another iterator to iterate the given procedure

No result value.

Purity of the procedure: nonpure

This procedure maps pairwise the given procedure to all the elements yielded by the iterators.

gen-generator

Syntax:

```
(gen-generator generator terminate? consumer iterator-inst)
```

Type parameters: %source, %target

Arguments:

Name: `generator`
 Type: (:procedure () %source nonpure)
 Description: A generator from which to create an iterator

Name: `terminate?`
 Type: (:procedure (%source) <boolean> pure)
 Description: A procedure that determines when to end the iteration

Name: `consumer`
 Type: (:nonpure-consumer %source %target)
 Description: A consumer procedure

Name: `iterator-inst`
 Type: (:nonpure-iterator-inst %source %target)

Description: An iterator instance

Result value: Target object

Result type: %target

Purity of the procedure: nonpure

This procedure is used internally to create an iterator from a generator.

generator->iterator

Syntax:

```
(generator->iterator generator terminate?)
```

Type parameters: %source

Arguments:

Name: `generator`

Type: `(:procedure () %source nonpure)`

Description: A generator from which to create an iterator

Name: `terminate?`

Type: `(:procedure (%source) <boolean> pure)`

Description: A procedure that determines when to end the iteration

Result value: An iterator for the given generator

Result type: `(:nonpure-iterator %source)`

Purity of the procedure: nonpure

This procedure is used to create an iterator that obtains its values from a generator.

Chapter 10

Module (standard-library object-string-output)

This module contains procedures to compute string output for different objects.

10.1 Simple Procedures

`boolean->string`

Syntax:

```
(boolean->string obj)
```

Arguments:

Name: `obj`
Type: `<boolean>`
Description: A boolean value

Result value: `"#t"` or `"#f"`

Result type: `<string>`

Purity of the procedure: pure

`boolean-to-string`

Syntax:

```
(boolean-to-string obj repr?)
```

Arguments:

Name: `obj`
Type: `<boolean>`
Description: A boolean value

Name: `repr?`
Type: `<boolean>`
Description: `#t` to give the source code representation (no effect in this procedure)

Result value: `"#t"` or `"#f"`
Result type: `<string>`

Purity of the procedure: pure

`character->string`

Syntax:

`(character->string obj)`

Arguments:

Name: `obj`
Type: `<character>`
Description: A character value

Result value: Return a string consisting of the given character
Result type: `<string>`

Purity of the procedure: pure

`character-to-string`

Syntax:

`(character-to-string obj repr?)`

Arguments:

Name: `obj`
Type: `<character>`

Description: A character value

Name: `repr?`

Type: `<boolean>`

Description: `#t` to give the source code representation

Result value: If `repr?` is `#t` return a string of the form `#\c` else return a string consisting of the given character

Result type: `<string>`

Purity of the procedure: pure

`general-atom-to-string`

Syntax:

```
(general-atom-to-string obj repr?)
```

Arguments:

Name: `obj`

Type: `<object>`

Description: An arbitrary object

Name: `repr?`

Type: `<boolean>`

Description: `#t` to give the source code representation (no effect in this procedure)

Result value: The name of the class of `obj` in brackets

Result type: `<string>`

Purity of the procedure: pure

`integer->string`

Syntax:

```
(integer->string obj)
```

Arguments:

Name: `obj`

Type: `<integer>`
Description: An integer value

Result value: Output string for the given value
Result type: `<string>`

Purity of the procedure: pure

`integer-to-string`

Syntax:

```
(integer-to-string obj repr?)
```

Arguments:

Name: `obj`
Type: `<integer>`
Description: An integer value

Name: `repr?`
Type: `<boolean>`
Description: `#t` to give the source code representation (no effect in this procedure)

Result value: Output string for the given value
Result type: `<string>`

Purity of the procedure: pure

`null->string`

Syntax:

```
(null->string obj)
```

Arguments:

Name: `obj`
Type: `<null>`
Description: `null`

Result value: `()`

Result type: <string>

Purity of the procedure: pure

null-to-string

Syntax:

```
(null-to-string obj repr?)
```

Arguments:

Name: obj
Type: <null>
Description: null

Name: repr?
Type: <boolean>
Description: #t to give the source code representation (no effect in this procedure)

Result value: "null"

Result type: <string>

Purity of the procedure: pure

real->string

Syntax:

```
(real->string obj)
```

Arguments:

Name: obj
Type: <real>
Description: A real value

Result value: Output string for the given value

Result type: <string>

Purity of the procedure: pure

real-to-string

Syntax:

```
(real-to-string obj repr?)
```

Arguments:

Name: `obj`
Type: `<real>`
Description: A real value

Name: `repr?`
Type: `<boolean>`
Description: `#t` to give the source code representation (no effect in this procedure)

Result value: Output string for the given value

Result type: `<string>`

Purity of the procedure: pure

string-to-display

Syntax:

```
(string-to-display obj)
```

Arguments:

Name: `obj`
Type: `<object>`
Description: An object

Result value: Output string for the given object (as in Scheme `display`)

Result type: `<string>`

Purity of the procedure: pure

string-to-string

Syntax:

```
(string-to-string obj repr?)
```

Arguments:

Name: `obj`
Type: `<string>`
Description: A string

Name: `repr?`
Type: `<boolean>`
Description: `#t` to give the source code representation

Result value: If `repr?` is `#t` return the string enclosed in double quotes else return the argument string without modifications

Result type: `<string>`

Purity of the procedure: pure

string-to-write

Syntax:

```
(string-to-display obj)
```

Arguments:

Name: `obj`
Type: `<object>`
Description: An object

Result value: Output string for the given object in source code representation (as in Scheme `write`)

Result type: `<string>`

symbol->string

Syntax:

```
(symbol->string obj)
```

Arguments:

Name: `obj`

Type: <symbol>
Description: A symbol

Result value: Output string for the given value
Result type: <string>

Purity of the procedure: pure

symbol-to-string

Syntax:

(symbol-to-string obj repr?)

Arguments:

Name: obj
Type: <symbol>
Description: A symbol

Name: repr?
Type: <boolean>
Description: #t to give the source code representation (no effect in this procedure)

Result value: Output string for the given value
Result type: <string>

Purity of the procedure: pure

to-string

Syntax:

(to-string obj repr?)

Arguments:

Name: obj
Type: <object>
Description: An object

Name: repr?

Type: `<boolean>`

Description: `#t` to give the source code representation

Result value: Output string for the given object

Result type: `<string>`

Purity of the procedure: pure

10.2 Methods

```
atom-to-string: (<object> <boolean>) → <string> pure = general-atom-to-string
atom-to-string: (<integer> <boolean>) → <string> pure = integer-to-string
atom-to-string: (<real> <boolean>) → <string> pure = real-to-string
string-to-string: (<string> <boolean>) → <string> pure = string-to-string
atom-to-string: (<symbol> <boolean>) → <string> pure = symbol-to-string
atom-to-string: (<null> <boolean>) → <string> pure = null-to-string
atom-to-string: (<character> <boolean>) → <string> pure = character-to-string
atom-to-string: (<boolean> <boolean>) → <string> pure = boolean-to-string
```


Chapter 11

Module (standard-library text-file-io)

11.1 Data Types

Data type name: <input-port>

Type: <class>

Description: An input port (input file)

Data type name: <output-port>

Type: <class>

Description: An output port (output file)

11.2 Simple Procedures

character-ready?

Syntax:

(character-ready? input-port)

Arguments:

Name: input-port

Type: <input-port>

Description: The input port to check

Result value: #t iff there is a character ready in the given input port

Result type: <boolean>

On i/o error exception (`io-error character-ready?:runtime-error file-name`) is raised.

close-input-port

Syntax:

```
(close-input-port input-port)
```

Arguments:

Name: `input-port`

Type: `<input-port>`

Description: The input port to be closed

No result value.

close-output-port

Syntax:

```
(close-output-port output-port)
```

Arguments:

Name: `output-port`

Type: `<output-port>`

Description: The output port to be closed

No result value.

current-input-port

Syntax:

```
(current-input-port)
```

No arguments.

Result value: The current input port

Result type: `<input-port>`

current-output-port

Syntax:

```
(current-output-port)
```

No arguments.

Result value: The current output port

Result type: <output-port>

display

Syntax:

```
(display output-port obj)
```

Arguments:

Name: `output-port`

Type: <output-port>

Description: An output port where to display

Name: `obj`

Type: <object>

Description: An object to be displayed

No result value.

This function uses the procedure `atom-to-string` to obtain the string representation of the object and displays the string with procedure `display-string`.

display-character

Syntax:

```
(display-character output-port ch)
```

Arguments:

Name: `output-port`

Type: <output-port>

Description: An output port where to display

Name: `ch`
Type: `<character>`
Description: A character to be displayed

No result value.

This procedure displays a character into the given output port. If the operation fails an exception (`io-error error-displaying-object filename`) is raised.

display-line

Syntax:

```
(display-line output-port obj)
```

Arguments:

Name: `output-port`
Type: `<output-port>`
Description: An output port where to display

Name: `obj`
Type: `<object>`
Description: An object to be displayed

No result value.

This function uses the procedure `atom-to-string` to obtain the string representation of the object and displays the string with procedure `display-string`. A newline is displayed after the object.

display-string

Syntax:

```
(display-string output-port str)
```

Arguments:

Name: `output-port`
Type: `<output-port>`
Description: An output port where to display

Name: `str`
Type: `<string>`

Description: A string to be displayed

No result value.

This procedure displays a string into the given output port. If the operation fails an exception (`io-error error-displaying-object filename`) is raised.

newline

Syntax:

```
(newline output-port)
```

Arguments:

Name: `output-port`
Type: `<output-port>`
Description: An output port where to print

No result value.

This procedure prints a newline to the given output port. If the operation fails an exception (`io-error error-displaying-newline filename`) is raised.

open-input-file

Syntax:

```
(open-input-file filename)
```

Arguments:

Name: `filename`
Type: `<string>`
Description: Name of the file to be opened

Result value: An object representing the opened file

Result type: `<input-port>`

This procedure opens an input file. If the operation fails an exception (`io-error error-opening-input-file filename`) is raised.

open-output-file

Syntax:

```
(open-output-file filename)
```

Arguments:

Name: `filename`
Type: `<string>`
Description: Name of the file to be opened

Result value: An object representing the opened file

Result type: `<output-port>`

This procedure opens an output file. If the operation fails an exception (`io-error error-opening-output-file filename`) is raised.

peek-character

Syntax:

```
(peek-character input-port)
```

Arguments:

Name: `input-port`
Type: `<input-port>`
Description: An input port where to read from

Result value: The read character or an eof object

Result type: `(:union <character> <eof>)`

This procedure peeks a character from an input port. On i/o error an exception (`io-error peek-character:io-error filename`) is raised.

read

Syntax:

```
(read input-port)
```

Arguments:

Name: `input-port`
Type: `<input-port>`
Description: An input port where to read from

Result value: The object read or an eof object

Result type: <object>

This procedure reads a Theme-D expression from an input port. The Theme-D runtime environment checks that the result object does not contain any data types unknown to Theme-D. On i/o error an exception (`io-error read:io-error filename`) is raised. If a Scheme vector constant is encountered in the data raise exception (`io-error io:illegal-vector filename`). If a Scheme complex number is encountered in the data raise exception (`io-error io:illegal-complex-number filename`). On some other Scheme object whose data type is not known by Theme-D raise exception (`io-error io:illegal-data-type filename`).

read-all

Syntax:

```
(read-all input-port)
```

Arguments:

Name: `input-port`

Type: <input-port>

Description: An input port where to read from

Result value: The objects read

Result type: <object>

This procedure uses procedure `read` to read all the expressions from the given input-port.

read-character

Syntax:

```
(read-character input-port)
```

Arguments:

Name: `input-port`

Type: <input-port>

Description: An input port where to read from

Result value: The read character or an eof object

Result type: (:union <character> <eof>)

This procedure reads a character from an input port. On i/o error an exception (`io-error read-character:io-error filename`) is raised.

read-line

Syntax:

```
(read-line input-port)
```

Arguments:

Name: `input-port`

Type: `<input-port>`

Description: An input port where to read from

Result value: Contents of a line

Result type: `<string>`

This procedure reads a single line from the given input port as a string. On i/o error an exception (`io-error read-character:io-error filename`) is raised.

read-string

Syntax:

```
(read-string input-port)
```

Arguments:

Name: `input-port`

Type: `<input-port>`

Description: An input port where to read from

Result value: The contents of the file

Result type: `<string>`

This procedure reads the contents of the given input port as a single string.

write

Syntax:

```
(write output-port obj)
```


Arguments:

Name: `output-port`
Type: `<output-port>`
Description: An output port where to write

Name: `obj`
Type: `<object>`
Description: An object to be written

No result value.

This function uses the procedure `atom-to-string` to obtain the source code representation of the object and displays the string with procedure `display-string`.

write-line*Syntax:*

```
(write-line output-port obj)
```

Arguments:

Name: `output-port`
Type: `<output-port>`
Description: An output port where to write

Name: `obj`
Type: `<object>`
Description: An object to be written

No result value.

This function uses the procedure `atom-to-string` to obtain the source code representation of the object and displays the string with procedure `display-string`. A newline is written after the object.

Chapter 12

Module (standard-library console-io)

This module implements input and output for the standard input and standard output.

12.1 Simple Procedures

console-character-ready?

Syntax:

```
(console-character-ready?)
```

No arguments.

Result value: #t iff there is a character ready in the standard input

Result type: <boolean>

console-display

Syntax:

```
(console-display obj)
```

Arguments:

Name: obj

Type: <object>

Description: An object to be displayed

No result value.

This function uses the procedure `atom-to-string` to obtain the string representation of the object and displays the string with procedure `console-display-string`.

`console-display-character`

Syntax:

```
(console-display-character ch)
```

Arguments:

Name: `ch`
Type: `<character>`
Description: A character to be displayed

No result value.

`console-display-line`

Syntax:

```
(console-display-line obj)
```

Arguments:

Name: `obj`
Type: `<object>`
Description: An object to be displayed

No result value.

This function uses the procedure `atom-to-string` to obtain the string representation of the object and displays the string with procedure `console-display-string`. A newline is displayed after the object.

`console-display-string`

Syntax:

```
(console-display-string str)
```

Arguments:

Name: `str`
Type: `<string>`
Description: A string to be displayed

No result value.

console-newline

Syntax:

```
(console-newline)
```

No arguments.

No result value.

This procedure prints a newline to the standard output.

console-read

Syntax:

```
(console-read)
```

No arguments.

Result value: The object read or an eof object

Result type: `<object>`

The Theme-D runtime environment checks that the result object does not contain any data types unknown to Theme-D.

console-read-character

Syntax:

```
(console-read-character)
```

No arguments.

Result value: The read character or an eof object

Result type: (:union <character> <eof>)

This procedure reads a character from the standard input.

console-write

Syntax:

```
(console-write obj)
```

Arguments:

Name: `obj`

Type: <object>

Description: An object to be written

No result value.

This function uses the procedure `atom-to-string` to obtain the source code representation of the object and displays the string with procedure `console-display-string`.

console-write-line

Syntax:

```
(console-write-line obj)
```

Arguments:

Name: `obj`

Type: <object>

Description: An object to be written

No result value.

This function uses the procedure `atom-to-string` to obtain the source code representation of the object and displays the string with procedure `console-display-string`. A newline is written after the object.

Chapter 13

Module (standard-library system)

13.1 Simple Procedures

delete-file

Syntax:

```
(delete-file str-filename)
```

Arguments:

Name: `str-filename`

Type: `<string>`

Description: The name of the file to be deleted

No result value.

Purity of the procedure: nonpure

This procedure deletes the named file. If the file does not exist an exception in raised.

file-exists?

Syntax:

```
(file-exists? str-filename)
```

Arguments:

Name: `str-filename`
Type: `<string>`
Description: The name of the file

Result value: Returns `#t` iff the file exists

Result type: `<boolean>`

Purity of the procedure: pure

getenv

Syntax:

```
(getenv str-var-name)
```

Arguments:

Name: `str-var-name`
Type: `<string>`
Description: The name of the environment variable

Result value: The value of the given environment variable

Result type: `(:maybe <string>)`

Purity of the procedure: pure

If the environment variable does not exist return `()`.

Chapter 14

Module (standard-library rational)

14.1 Data Types

Data type name: <rational>

Type: <class>

Description: A rational number

Class <rational> is immutable, equal by value, and not inheritable.

Data type name: <rational-number>

Type: :union

Description: A rational valued number

Type <rational-number> is equal to the union of <rational> and <integer>.

14.2 Simple Procedures

rational

Syntax:

(rational i-numer i-denom)

Arguments:

Name: i-numer

Type: <integer>

Description: The numerator

Name: `i-denom`
Type: `<integer>`
Description: The denominator

Result value: The quotient of `i-numer` and `i-denom`

Result type: `<rational>`

Purity of the procedure: pure

This procedure returns the rational number in simplified form. If the denominator is zero a numerical overflow exception is raised.

numerator

Syntax:

```
(numerator rat)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational number

Result value: The numerator of the argument

Result type: `<integer>`

Purity of the procedure: pure

denominator

Syntax:

```
(denominator rat)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational number

Result value: The denominator of the argument

Result type: `<integer>`

Purity of the procedure: pure

rational=?

Syntax:

```
(rational=? rat1 rat2)
```

Arguments:

Name: `rat1`
Type: `<rational>`
Description: A rational value to be compared

Name: `rat2`
Type: `<rational>`
Description: A rational value to be compared

Result value: `#t` iff `rat1` is equal to `rat2`

Result type: `<boolean>`

Purity of the procedure: pure

Rational numbers a/b and c/d are equal iff $ad = bc$.

rational-integer=?

Syntax:

```
(rational-integer=? rat i)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value to be compared

Name: `i`
Type: `<integer>`
Description: An integer value to be compared

Result value: `#t` iff `rat` is equal to `i`

Result type: `<boolean>`

Rational number a/b and integer c are equal iff $a = bc$.
Purity of the procedure: pure

integer-rational=?

Syntax:

```
(integer-rational=? i rat)
```

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer value to be compared

Name: `rat`
Type: `<rational>`
Description: A rational value to be compared

Result value: `#t` iff `i` is equal to `rat`
Result type: `<boolean>`

rational<

Syntax:

```
(rational< rat1 rat2)
```

Arguments:

Name: `rat1`
Type: `<rational>`
Description: A rational value to be compared

Name: `rat2`
Type: `<rational>`
Description: A rational value to be compared

Result value: `#t` iff `rat1` is less than `rat2`
Result type: `<boolean>`

Purity of the procedure: pure

rational-integer<*Syntax:*

```
(rational-integer< rat i)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value to be compared

Name: `i`
Type: `<integer>`
Description: An integer value to be compared

Result value: `#t` iff `rat` is less than `i`*Result type:* `<boolean>`*Purity of the procedure:* pure**integer-rational<***Syntax:*

```
(integer-rational< i rat)
```

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer value to be compared

Name: `rat`
Type: `<rational>`
Description: A rational value to be compared

Result value: `#t` iff `i` is less than `rat`*Result type:* `<boolean>`**rational<=***Syntax:*

```
(rational<= rat1 rat2)
```

Arguments:

Name: `rat1`
Type: `<rational>`
Description: A rational value to be compared

Name: `rat2`
Type: `<rational>`
Description: A rational value to be compared

Result value: `#t` iff `rat1` is less than or equal to `rat2`

Result type: `<boolean>`

Purity of the procedure: pure

`rational-integer<=`

Syntax:

```
(rational-integer<= rat i)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value to be compared

Name: `i`
Type: `<integer>`
Description: An integer value to be compared

Result value: `#t` iff `rat` is less than or equal to `i`

Result type: `<boolean>`

Purity of the procedure: pure

`integer-rational<=`

Syntax:

```
(integer-rational<= i rat)
```

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer value to be compared

Name: `rat`
Type: `<rational>`
Description: A rational value to be compared

Result value: `#t` iff `i` is less than or equal to `rat`

Result type: `<boolean>`

`rational>`

Syntax:

`(rational> rat1 rat2)`

Arguments:

Name: `rat1`
Type: `<rational>`
Description: A rational value to be compared

Name: `rat2`
Type: `<rational>`
Description: A rational value to be compared

Result value: `#t` iff `rat1` is greater than `rat2`

Result type: `<boolean>`

Purity of the procedure: pure

`rational-integer>`

Syntax:

`(rational-integer> rat i)`

Arguments:

Name: `rat`

Type: `<rational>`
Description: A rational value to be compared

Name: `i`
Type: `<integer>`
Description: An integer value to be compared

Result value: `#t` iff `rat` is greater than `i`
Result type: `<boolean>`

Purity of the procedure: pure

`integer-rational>`

Syntax:

```
(integer-rational> i rat)
```

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer value to be compared

Name: `rat`
Type: `<rational>`
Description: A rational value to be compared

Result value: `#t` iff `i` is greater than `rat`
Result type: `<boolean>`

`rational>=`

Syntax:

```
(rational>= rat1 rat2)
```

Arguments:

Name: `rat1`
Type: `<rational>`
Description: A rational value to be compared

Name: `rat2`
Type: `<rational>`
Description: A rational value to be compared

Result value: `#t` iff `rat1` is greater than or equal to `rat2`
Result type: `<boolean>`

Purity of the procedure: pure

`rational-integer>=`

Syntax:

```
(rational-integer>= rat i)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value to be compared

Name: `i`
Type: `<integer>`
Description: An integer value to be compared

Result value: `#t` iff `rat` is greater than or equal to `i`
Result type: `<boolean>`

Purity of the procedure: pure

`integer-rational>=`

Syntax:

```
(integer-rational>= i rat)
```

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer value to be compared

Name: `rat`

Type: `<rational>`

Description: A rational value to be compared

Result value: `#t` iff `i` is greater than or equal to `rat`

Result type: `<boolean>`

Purity of the procedure: pure

`simplify-rational`

Syntax:

```
(simplify-rational rat)
```

Arguments:

Name: `rat`

Type: `<rational>`

Description: A rational value

Result value: The argument in the simplified form

Result type: `<rational>`

Purity of the procedure: pure

See chapter 2.

`rat-integer-valued?`

Syntax:

```
(rat-integer-valued? rat)
```

Arguments:

Name: `rat`

Type: `<rational>`

Description: A rational value

Result value: `#t` iff the argument is integer valued

Result type: `<boolean>`

Purity of the procedure: pure

A rational number is integer valued iff its denominator is 1 in the simplified form.

rat-sign

Syntax:

```
(rat-sign rat)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value

Result value: The sign of the argument

Result type: `<integer>`

Purity of the procedure: pure

Return 0 if `rat = 0`, 1 if `rat > 0`, and -1 if `rat < 0`.

integer->rational

Syntax:

```
(integer->rational i)
```

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer value

Result value: The argument converted to a rational number

Result type: `<rational>`

Purity of the procedure: pure

The numerator of the result is `i` and the denominator 1.

rational->integer

Syntax:

(rational->integer rat)

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value

Result value: The argument converted to an integer number

Result type: `<integer>`

Purity of the procedure: pure

If the argument is not integer valued an exception `rational->integer:not-an-integer` is raised.

`rat-zero`

Syntax:

(rat-zero)

No arguments.

Result value: The rational number 0

Result type: `<rational>`

Purity of the procedure: pure

The numerator of the result is 0 and the denominator 1.

`rat-one`

Syntax:

(rat-one)

No arguments.

Result value: The rational number 1

Result type: `<rational>`

Purity of the procedure: pure

The numerator and the denominator of the result are 1.

rat-zero?

Syntax:

```
(rat-zero? rat)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value

Result value: `#t` iff the argument is equal to 0

Result type: `<boolean>`

Purity of the procedure: pure

A numerical overflow exception is raised if the denominator of the argument is 0.

rat-one?

Syntax:

```
(rat-one? rat)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value

Result value: `#t` iff the argument is equal to 1

Result type: `<boolean>`

Purity of the procedure: pure

A numerical overflow exception is raised if the denominator of the argument is 0.

rational+

Syntax:

```
(rational+ rat1 rat2)
```

Arguments:

Name: `rat1`
Type: `<rational>`
Description: A rational value

Name: `rat2`
Type: `<rational>`
Description: A rational value

Result value: The sum of the arguments in the simplified form

Result type: `<rational>`

Purity of the procedure: pure

rational-integer+*Syntax:*

`(rational-integer+ rat i)`

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value

Name: `i`
Type: `<integer>`
Description: An integer value

Result value: The sum of the arguments in the simplified form

Result type: `<rational>`

Purity of the procedure: pure

integer-rational+*Syntax:*

`(integer-rational+ i rat)`

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer value

Name: `rat`
Type: `<rational>`
Description: A rational value

Result value: The sum of the arguments in the simplified form

Result type: `<rational>`

Purity of the procedure: pure

rational-

Syntax:

```
(rational- rat1 rat2)
```

Arguments:

Name: `rat1`
Type: `<rational>`
Description: A rational value

Name: `rat2`
Type: `<rational>`
Description: A rational value

Result value: The difference of the arguments in the simplified form

Result type: `<rational>`

Purity of the procedure: pure

rational-integer-

Syntax:

```
(rational-integer- rat i)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value

Name: `i`
Type: `<integer>`
Description: An integer value

Result value: The difference of the arguments in the simplified form
Result type: `<rational>`

Purity of the procedure: pure

`integer-rational-`

Syntax:

```
(integer-rational- i rat)
```

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer value

Name: `rat`
Type: `<rational>`
Description: A rational value

Result value: The difference of the arguments in the simplified form
Result type: `<rational>`

Purity of the procedure: pure

`rational*`

Syntax:

```
(rational* rat1 rat2)
```

Arguments:

Name: `rat1`

Type: <rational>
Description: A rational value

Name: `rat2`
Type: <rational>
Description: A rational value

Result value: The product of the arguments in the simplified form

Result type: <rational>

Purity of the procedure: pure

`rational-integer*`

Syntax:

```
(rational-integer* rat i)
```

Arguments:

Name: `rat`
Type: <rational>
Description: A rational value

Name: `i`
Type: <integer>
Description: An integer value

Result value: The product of the arguments in the simplified form

Result type: <rational>

Purity of the procedure: pure

`integer-rational*`

Syntax:

```
(integer-rational* i rat)
```

Arguments:

Name: `i`
Type: <integer>

Description: An integer value

Name: `rat`

Type: `<rational>`

Description: A rational value

Result value: The product of the arguments in the simplified form

Result type: `<rational>`

Purity of the procedure: pure

`rational/`

Syntax:

```
(rational/ rat1 rat2)
```

Arguments:

Name: `rat1`

Type: `<rational>`

Description: A rational value

Name: `rat2`

Type: `<rational>`

Description: A rational value

Result value: The quotient of the arguments in the simplified form

Result type: `<rational>`

Purity of the procedure: pure

If the divisor is equal to 0 raise a numerical overflow exception.

`rational-integer/`

Syntax:

```
(rational-integer/ rat i)
```

Arguments:

Name: `rat`

Type: `<rational>`

Description: A rational value

Name: `i`

Type: `<integer>`

Description: An integer value

Result value: The quotient of the arguments in the simplified form

Result type: `<rational>`

Purity of the procedure: pure

If the divisor is equal to 0 raise a numerical overflow exception.

`integer-rational/`

Syntax:

```
(integer-rational/ i rat)
```

Arguments:

Name: `i`

Type: `<integer>`

Description: An integer value

Name: `rat`

Type: `<rational>`

Description: A rational value

Result value: The quotient of the arguments in the simplified form

Result type: `<rational>`

Purity of the procedure: pure

If the divisor is equal to 0 raise a numerical overflow exception.

`rat-neg`

Syntax:

```
(rat-neg rat)
```

Arguments:

Name: `rat`

Type: `<rational>`
Description: A rational value

Result value: The opposite of the argument
Result type: `<rational>`

Purity of the procedure: pure

rat-abs

Syntax:

```
(rat-abs rat)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value

Result value: The absolute value of the argument
Result type: `<rational>`

Purity of the procedure: pure

rat-square

Syntax:

```
(rat-square rat)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value

Result value: The square of the argument
Result type: `<rational>`

Purity of the procedure: pure

rat-inverse

Syntax:

```
(rat-inverse rat)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value

Result value: The inverse of the argument

Result type: `<rational>`

Purity of the procedure: pure

If the argument is equal to 0 a numerical overflow exception is raised.

rat-nonneg-int-expt

Syntax:

```
(rat-nonneg-int-expt rat-base i-exponent)
```

Arguments:

Name: `rat-base`
Type: `<rational>`
Description: A rational value

Name: `i-exponent`
Type: `<integer>`
Description: A nonnegative integer value

Result value: `rat-base` raised to the power `i-exponent`

Result type: `<rational>`

Purity of the procedure: pure

rat-int-expt

Syntax:

`(rat-int-expt rat-base i-exponent)`

Arguments:

Name: `rat-base`
Type: `<rational>`
Description: A rational value

Name: `i-exponent`
Type: `<integer>`
Description: An integer value

Result value: `rat-base` raised to the power `i-exponent`

Result type: `<rational>`

Purity of the procedure: pure

If `rat-base` is equal to 0 and `i-exponent` is negative raise a numerical overflow exception.

`i-expt`

Syntax:

`(i-expt i-base i-exponent)`

Arguments:

Name: `i-base`
Type: `<integer>`
Description: An integer number

Name: `i-exponent`
Type: `<integer>`
Description: An integer number

Result value: `i-base` raised to the power `i-exponent`

Result type: `<rational-number>`

Purity of the procedure: pure

If the base is 0 and the exponent is negative raise a numerical overflow exception. If the exponent is nonnegative the result is always an `<integer>`.

`rat-log10-exact`

Syntax:

```
(rat-log10-exact rat)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational number

Result value: The base 10 logarithm of the argument or `null` if the logarithm is not an integer

Result type: `(:maybe <integer>)`

Purity of the procedure: pure

This procedure is able compute logarithms of the negative integer powers of 10, too.

rat-log2-exact

Syntax:

```
(rat-log2-exact rat)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational number

Result value: The base 2 logarithm of the argument or `null` if the logarithm is not an integer

Result type: `(:maybe <integer>)`

Purity of the procedure: pure

This procedure is able compute logarithms of the negative integer powers of 2, too.

rational-to-string

Syntax:

```
(rational-to-string rat repr?)
```

Arguments:

Name: `rat`
 Type: `<rational>`
 Description: A rational value

Name: `repr?`
 Type: `<boolean>`
 Description: Should we write a representation or a user-friendly value

Result value: The argument value converted to a string

Result type: `<string>`

Purity of the procedure: pure

14.3 Methods

`equal?: (<rational> <rational>) → <boolean> pure = rational=?`
`equal?: (<rational> <integer>) → <boolean> pure = rational-integer=?`
`equal?: (<integer> <rational>) → <boolean> pure = integer-rational=?`

`<: (<rational-number> <rational-number>) → <boolean> pure abstract`
`<: (<rational> <rational>) → <boolean> pure = rational<`
`<: (<rational> <integer>) → <boolean> pure = rational-integer<`
`<: (<integer> <rational>) → <boolean> pure = integer-rational<`

`<=: (<rational-number> <rational-number>) → <boolean> pure abstract`
`<=: (<rational> <rational>) → <boolean> pure = rational<=`
`<=: (<rational> <integer>) → <boolean> pure = rational-integer<=`
`<=: (<integer> <rational>) → <boolean> pure = integer-rational<=`

`>: (<rational-number> <rational-number>) → <boolean> pure abstract`
`>: (<rational> <rational>) → <boolean> pure = rational>`
`>: (<rational> <integer>) → <boolean> pure = rational-integer>`
`>: (<integer> <rational>) → <boolean> pure = integer-rational>`

`>=: (<rational-number> <rational-number>) → <boolean> pure abstract`
`>=: (<rational> <rational>) → <boolean> pure = rational>=`
`>=: (<rational> <integer>) → <boolean> pure = rational-integer>=`
`>=: (<integer> <rational>) → <boolean> pure = integer-rational>=`

`+: (<rational-number> <rational-number>) → <rational-number> pure abstract`
`+: (<rational> <rational>) → <rational> pure = rational+`
`+: (<rational> <integer>) → <rational> pure = rational-integer+`
`+: (<integer> <rational>) → <rational> pure = integer-rational+`


```

-: (<rational-number> <rational-number>) → <rational-number> pure
abstract
-: (<rational> <rational>) → <rational> pure = rational-
-: (<rational> <integer>) → <rational> pure = rational-integer-
-: (<integer> <rational>) → <rational> pure = integer-rational-

*: (<rational-number> <rational-number>) → <rational-number> pure
abstract
*: (<rational> <rational>) → <rational> pure = rational*
*: (<rational> <integer>) → <rational> pure = rational-integer*
*: (<integer> <rational>) → <rational> pure = integer-rational*

/: (<rational-number> <rational-number>) → <rational-number> pure
abstract
/: (<rational> <rational>) → <rational> pure = rational/
/: (<rational> <integer>) → <rational> pure = rational-integer/
/: (<integer> <rational>) → <rational> pure = integer-rational/

-: (<rational-number>) → <rational-number> pure abstract
-: (<rational>) → <rational> pure = rat-neg

abs: (<rational-number>) → <rational-number> pure abstract
abs: (<rational>) → <rational> pure = rat-abs

square: (<rational-number>) → <rational-number> pure abstract
square: (<rational>) → <rational> pure = rat-square

sign: (<rational-number>) → <rational-number> pure abstract
sign: (<rational>) → <integer> pure = rat-sign

atom-to-string: (<rational> <boolean>) → <string> pure = rational-to-string

```


Chapter 15

Module (standard-library real-math)

15.1 Data Types

Data type name: <real-number>

Type: :union

Description: A real valued number

Type <real-number> is equal to the union of <real>, <rational>, and <integer>.

15.2 Constants

The following constants are defined:

- `gl-r-pi`: The value π
- `gl-r-pi/2`: The value $\pi/2$
- `gl-r-pi/4`: The value $\pi/4$
- `gl-r-1/pi`: The value $1/\pi$
- `gl-r-2/pi`: The value $2/\pi$
- `gl-r-2/sqrtpi`: The value $1/\sqrt{\pi}$
- `gl-r-sqrt2`: The value $\sqrt{2}$
- `gl-r-1/sqrt2`: The value $1/\sqrt{2}$
- `gl-r-e`: The value e (Napier's constant)
- `gl-r-log2e`: The value $\log_2 e$
- `gl-r-log10e`: The value $\log_{10} e$

- `gl-r-ln2`: The value $\ln 2$
- `gl-r-ln10`: The value $\ln 10$
- `gl-r-pi/ln2`: The value $\pi/\ln 2$
- `gl-r-pi/ln10`: The value $\pi/\ln 10$

15.3 Simple Procedures

`rational->real`

Syntax:

```
(rational->real rat)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value

Result value: The rational value converted to a real value

Result type: `<real>`

Purity of the procedure: pure

`real-rational=?`

Syntax:

```
(real-rational=? r rat)
```

Arguments:

Name: `r`
Type: `<real>`
Description: A real value to be compared

Name: `rat`
Type: `<rational>`
Description: A rational value to be compared

Result value: #t iff `r` is equal to `rat`

Result type: <boolean>

Purity of the procedure: pure

rational-real=?

Syntax:

```
(rational-real=? rat r)
```

Arguments:

Name: `rat`

Type: <rational>

Description: A rational value to be compared

Name: `r`

Type: <real>

Description: A real value to be compared

Result value: #t iff `rat` is equal to `r`

Result type: <boolean>

Purity of the procedure: pure

real-rational<

Syntax:

```
(real-rational< r rat)
```

Arguments:

Name: `r`

Type: <real>

Description: A real value to be compared

Name: `rat`

Type: <rational>

Description: A rational value to be compared

Result value: #t iff `r` is less than `rat`

Result type: <boolean>

Purity of the procedure: pure

rational-real<

Syntax:

(rational-real< rat r)

Arguments:

Name: `rat`

Type: <rational>

Description: A rational value to be compared

Name: `r`

Type: <real>

Description: A real value to be compared

Result value: #t iff `rat` is less than `r`

Result type: <boolean>

Purity of the procedure: pure

real-rational<=

Syntax:

(real-rational<= r rat)

Arguments:

Name: `r`

Type: <real>

Description: A real value to be compared

Name: `rat`

Type: <rational>

Description: A rational value to be compared

Result value: #t iff `r` is less than or equal to `rat`

Result type: <boolean>

Purity of the procedure: pure

rational-real<=

Syntax:

```
(rational-real<= rat r)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value to be compared

Name: `r`
Type: `<real>`
Description: A real value to be compared

Result value: `#t` iff `rat` is less than or equal to `r`

Result type: `<boolean>`

Purity of the procedure: pure

real-rational>

Syntax:

```
(real-rational> r rat)
```

Arguments:

Name: `r`
Type: `<real>`
Description: A real value to be compared

Name: `rat`
Type: `<rational>`
Description: A rational value to be compared

Result value: `#t` iff `r` is greater than `rat`

Result type: `<boolean>`

Purity of the procedure: pure

rational-real>

Syntax:

```
(rational-real> rat r)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value to be compared

Name: `r`
Type: `<real>`
Description: A real value to be compared

Result value: `#t` iff `rat` is greater than `r`

Result type: `<boolean>`

Purity of the procedure: pure

real-rational>=

Syntax:

```
(real-rational>= r rat)
```

Arguments:

Name: `r`
Type: `<real>`
Description: A real value to be compared

Name: `rat`
Type: `<rational>`
Description: A rational value to be compared

Result value: `#t` iff `r` is greater than or equal to `rat`

Result type: `<boolean>`

Purity of the procedure: pure

rational-real>=*Syntax:*

```
(rational-real>= rat r)
```

Arguments:

Name: **rat**
Type: **<rational>**
Description: A rational value to be compared

Name: **r**
Type: **<real>**
Description: A real value to be compared

Result value: **#t** iff **rat** is greater than or equal to **r***Result type:* **<boolean>***Purity of the procedure:* pure**real-rational+***Syntax:*

```
(real-rational+ r rat)
```

Arguments:

Name: **r**
Type: **<real>**
Description: A real value

Name: **rat**
Type: **<rational>**
Description: A rational value

Result value: The sum of the arguments*Result type:* **<real>***Purity of the procedure:* pure**rational-real+**

Syntax:

```
(rational-real+ rat r)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value

Name: `r`
Type: `<real>`
Description: A real value

Result value: The sum of the arguments

Result type: `<real>`

Purity of the procedure: pure

real-rational-

Syntax:

```
(real-rational- r rat)
```

Arguments:

Name: `r`
Type: `<real>`
Description: A real value

Name: `rat`
Type: `<rational>`
Description: A rational value

Result value: The difference of the arguments

Result type: `<real>`

Purity of the procedure: pure

rational-real-

Syntax:

(rational-real- rat r)

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value

Name: `r`
Type: `<real>`
Description: A real value

Result value: The difference of the arguments

Result type: `<real>`

Purity of the procedure: pure

real-rational*

Syntax:

(real-rational* r rat)

Arguments:

Name: `r`
Type: `<real>`
Description: A real value

Name: `rat`
Type: `<rational>`
Description: A rational value

Result value: The product of the arguments

Result type: `<real>`

Purity of the procedure: pure

rational-real*

Syntax:

(rational-real* rat r)

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value

Name: `r`
Type: `<real>`
Description: A real value

Result value: The product of the arguments

Result type: `<real>`

Purity of the procedure: pure

`real-rational/`*Syntax:*

`(real-rational/ r rat)`

Arguments:

Name: `r`
Type: `<real>`
Description: A real value

Name: `rat`
Type: `<rational>`
Description: A rational value

Result value: The quotient of the arguments

Result type: `<real>`

Purity of the procedure: pure

In case `rat` is equal to 0 return

- `inf`, if `rat > 0`
- `-inf`, if `rat < 0`
- `NaN`, if `rat = 0`

`rational-real/`

Syntax:

```
(rational-real/ rat r)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: A rational value

Name: `r`
Type: `<real>`
Description: A real value

Result value: The quotient of the arguments

Result type: `<real>`

Purity of the procedure: pure

In case `r` is equal to 0 return

- `inf`, if `r > 0`
- `-inf`, if `r < 0`
- `NaN`, if `r = 0`

`r-sqrt`

Syntax:

```
(r-sqrt r)
```

Arguments:

Name: `r`
Type: `<real>`
Description: A real number

Result value: Square root of the argument

Result type: `<real>`

Purity of the procedure: pure

If the argument is negative return `NaN`.

`r-expt`

Syntax:

(r-expt x y)

Arguments:

Name: x
Type: <real>
Description: A real number

Name: y
Type: <real>
Description: A real number

Result value: x to the power of y

Result type: <real>

Purity of the procedure: pure

If x is less than 0 return NaN. If x is equal to 0 return 1.0.

r-exp

Syntax:

(r-exp r)

Arguments:

Name: r
Type: <real>
Description: A real number

Result value: e to the power of r

Result type: <real>

Purity of the procedure: pure

Number e is the base of natural logarithms (approx. 2.718).

r-log

Syntax:

(r-log r)

Arguments:

Name: **r**
Type: **<real>**
Description: A real number

Result value: The natural logarithm of **r**
Result type: **<real>**

Purity of the procedure: pure

If the argument is 0.0 return -inf. If the argument is less than 0.0 return NaN.

r-log10

Syntax:

(**r-log10 r**)

Arguments:

Name: **r**
Type: **<real>**
Description: A real number

Result value: The base 10 logarithm of **r**
Result type: **<real>**

Purity of the procedure: pure

If the argument is 0.0 return -inf. If the argument is less than 0.0 return NaN.

r-sin

Syntax:

(**r-sin r**)

Arguments:

Name: **r**
Type: **<real>**
Description: A real number

Result value: The sine of the argument

Result type: <real>

Purity of the procedure: pure

r-cos

Syntax:

(r-cos r)

Arguments:

Name: r

Type: <real>

Description: A real number

Result value: The cosine of the argument

Result type: <real>

Purity of the procedure: pure

r-tan

Syntax:

(r-tan r)

Arguments:

Name: r

Type: <real>

Description: A real number

Result value: The tangent of the argument

Result type: <real>

Purity of the procedure: pure

r-asin

Syntax:

`(r-asin r)`

Arguments:

Name: `r`
Type: `<real>`
Description: A real number

Result value: The arcsine of the argument

Result type: `<real>`

Purity of the procedure: pure

If the result is not real return NaN.

r-acos

Syntax:

`(r-acos r)`

Arguments:

Name: `r`
Type: `<real>`
Description: A real number

Result value: The arccosine of the argument

Result type: `<real>`

Purity of the procedure: pure

If the result is not real return NaN.

r-atan

Syntax:

`(r-atan r)`

Arguments:

Name: `r`

Type: `<real>`
Description: A real number

Result value: The arctangent of the argument
Result type: `<real>`

Purity of the procedure: pure

r-sinh

Syntax:

`(r-sinh r)`

Arguments:

Name: `r`
Type: `<real>`
Description: A real number

Result value: The hyperbolic sine of the argument
Result type: `<real>`

Purity of the procedure: pure

r-cosh

Syntax:

`(r-cosh r)`

Arguments:

Name: `r`
Type: `<real>`
Description: A real number

Result value: The hyperbolic cosine of the argument
Result type: `<real>`

Purity of the procedure: pure

r-tanh*Syntax:* $(\text{r-tanh } r)$ *Arguments:*

Name: **r**
Type: **<real>**
Description: A real number

Result value: The hyperbolic tangent of the argument*Result type:* **<real>***Purity of the procedure:* pure**r-asinh***Syntax:* $(\text{r-asinh } r)$ *Arguments:*

Name: **r**
Type: **<real>**
Description: A real number

Result value: The hyperbolic arcsine of the argument*Result type:* **<real>***Purity of the procedure:* pure**r-acosh***Syntax:* $(\text{r-acosh } r)$ *Arguments:*

Name: **r**

Type: `<real>`
Description: A real number

Result value: The hyperbolic arccosine of the argument
Result type: `<real>`

Purity of the procedure: pure

If the result is not real return NaN.

`r-atanh`

Syntax:

`(r-atanh r)`

Arguments:

Name: `r`
Type: `<real>`
Description: A real number

Result value: The hyperbolic arctangent of the argument
Result type: `<real>`

Purity of the procedure: pure

If the result is not real return NaN.

`r-atan2`

Syntax:

`(r-atan2 y x)`

Arguments:

Name: `y`
Type: `<real>`
Description: A real number

Name: `x`
Type: `<real>`
Description: A real number

Result value: The angle between point (x, y) and the positive x axis (in radians)

Result type: <real>

Purity of the procedure: pure

i-sqrt

Syntax:

```
(i-sqrt i)
```

Arguments:

Name: i

Type: <integer>

Description: An integer number

Result value: Square root of the argument

Result type: (:union <real> <integer>)

Purity of the procedure: pure

If the square root is integer valued it is converted to class <integer>.

rat-sqrt

Syntax:

```
(rat-sqrt rat)
```

Arguments:

Name: rat

Type: <rational>

Description: A rational number

Result value: Square root of the argument

Result type: (:union <real> <rational> <integer>)

Purity of the procedure: pure

If the square root is rational or integer valued it is converted to class <rational> or <integer>, respectively.

15.4 Methods

```
equal?: (<real> <rational>) → <boolean> pure = real-rational=?
equal?: (<rational> <real>) → <boolean> pure = rational-real=?
```

```
<: (<real-number> <real-number>) → <boolean> pure abstract
<: (<real> <rational>) → <boolean> pure = real-rational<
<: (<rational> <real>) → <boolean> pure = rational-real<
<=: (<real-number> <real-number>) → <boolean> pure abstract
<=: (<real> <rational>) → <boolean> pure = real-rational<=
<=: (<rational> <real>) → <boolean> pure = rational-real<=
>: (<real-number> <real-number>) → <boolean> pure abstract
>: (<real> <rational>) → <boolean> pure = real-rational>
>: (<rational> <real>) → <boolean> pure = rational-real>
>=: (<real-number> <real-number>) → <boolean> pure abstract
>=: (<real> <rational>) → <boolean> pure = real-rational>=
>=: (<rational> <real>) → <boolean> pure = rational-real>=
```

```
+: (<real-number> <real-number>) → <real-number> pure abstract
+: (<real> <rational>) → <real> pure = real-rational+
+: (<rational> <real>) → <real> pure = rational-real+
-: (<real-number> <real-number>) → <real-number> pure abstract
-: (<real> <rational>) → <real> pure = real-rational-
-: (<rational> <real>) → <real> pure = rational-real-
*: (<real-number> <real-number>) → <real-number> pure abstract
*: (<real> <rational>) → <real> pure = real-rational*
*: (<rational> <real>) → <real> pure = rational-real*
/: (<real-number> <real-number>) → <real-number> pure abstract
/: (<real> <rational>) → <real> pure = real-rational/
/: (<rational> <real>) → <real> pure = rational-real/
```

```
-: (<real-number>) → <real-number> pure abstract
abs: (<real-number>) → <real-number> pure abstract
square: (<real-number>) → <real-number> pure abstract
sign: (<real-number>) → <integer> pure abstract
```

Chapter 16

Module (standard-library complex)

16.1 Data Types

Data type name: <complex>

Type: <class>

Description: A complex number

Class <complex> is immutable, equal by value, and not inheritable.

16.2 Simple Procedures

real->complex

Syntax:

(real->complex r)

Arguments:

Name: r

Type: <real>

Description: A real number

Result value: The complex number corresponding to the given real number

Result type: <complex>

Purity of the procedure: pure

integer->complex

Syntax:

(integer->complex n)

Arguments:

Name: n
Type: <integer>
Description: An integer number

Result value: The complex number corresponding to the given integer number

Result type: <complex>

Purity of the procedure: pure

rational->complex

Syntax:

(rational->complex rat)

Arguments:

Name: rat
Type: <rational>
Description: An integer number

Result value: The complex number corresponding to the given rational number

Result type: <complex>

Purity of the procedure: pure

complex=?

Syntax:

(complex=? cx1 cx2)

Arguments:

Name: cx1

Type: `<complex>`
 Description: A complex value to be compared

Name: `cx2`
 Type: `<complex>`
 Description: A complex value to be compared

Result value: `#t` iff `cx1` is equal to `cx2`

Result type: `<boolean>`

Purity of the procedure: pure

`complex-integer=?`

Syntax:

```
(complex-integer=? cx i)
```

Arguments:

Name: `cx`
 Type: `<complex>`
 Description: A complex value to be compared

Name: `i`
 Type: `<integer>`
 Description: An integer value to be compared

Result value: `#t` iff `cx` is equal to `i`

Result type: `<boolean>`

Purity of the procedure: pure

`integer-complex=?`

Syntax:

```
(integer-complex=? i cx)
```

Arguments:

Name: `i`
 Type: `<integer>`

Description: An integer value to be compared

Name: `cx`

Type: `<complex>`

Description: A complex value to be compared

Result value: `#t` iff `i` is equal to `cx`

Result type: `<boolean>`

Purity of the procedure: pure

`complex-real=?`

Syntax:

```
(complex-real=? cx r)
```

Arguments:

Name: `cx`

Type: `<complex>`

Description: A complex value to be compared

Name: `r`

Type: `<real>`

Description: A real value to be compared

Result value: `#t` iff `cx` is equal to `r`

Result type: `<boolean>`

Purity of the procedure: pure

`real-complex=?`

Syntax:

```
(real-complex=? r cx)
```

Arguments:

Name: `r`

Type: `<real>`

Description: A real value to be compared

Name: `cx`
Type: `<complex>`
Description: A complex value to be compared

Result value: `#t` iff `r` is equal to `cx`

Result type: `<boolean>`

Purity of the procedure: pure

`complex-rational=?`

Syntax:

```
(complex-rational=? cx rat)
```

Arguments:

Name: `cx`
Type: `<complex>`
Description: A complex value to be compared

Name: `rat`
Type: `<rational>`
Description: A rational value to be compared

Result value: `#t` iff `cx` is equal to `rat`

Result type: `<boolean>`

Purity of the procedure: pure

`rational-complex=?`

Syntax:

```
(rational-complex=? rat cx)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: An rational value to be compared

Name: `cx`
Type: `<complex>`
Description: A complex value to be compared

Result value: `#t` iff `rat` is equal to `cx`
Result type: `<boolean>`

Purity of the procedure: pure

`complex+`

Syntax:

```
(complex+ cx1 cx2)
```

Arguments:

Name: `cx1`
Type: `<complex>`
Description: A complex value

Name: `cx2`
Type: `<complex>`
Description: A complex value

Result value: The sum of the arguments
Result type: `<complex>`

Purity of the procedure: pure

`complex-integer+`

Syntax:

```
(complex-integer+ cx i)
```

Arguments:

Name: `cx`
Type: `<complex>`
Description: A complex value

Name: `i`

Type: `<integer>`
Description: An integer value

Result value: The sum of the arguments

Result type: `<complex>`

Purity of the procedure: pure

`integer-complex+`

Syntax:

```
(integer-complex+ i cx)
```

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer value

Name: `cx`
Type: `<complex>`
Description: A complex value

Result value: The sum of the arguments

Result type: `<complex>`

Purity of the procedure: pure

`complex-real+`

Syntax:

```
(complex-real+ cx r)
```

Arguments:

Name: `cx`
Type: `<complex>`
Description: A complex value

Name: `r`
Type: `<real>`

Description: A real value

Result value: The sum of the arguments

Result type: <complex>

Purity of the procedure: pure

real-complex+

Syntax:

```
(real-complex+ r cx)
```

Arguments:

Name: r

Type: <real>

Description: A real value

Name: cx

Type: <complex>

Description: A complex value

Result value: The sum of the arguments

Result type: <complex>

Purity of the procedure: pure

complex-rational+

Syntax:

```
(complex-rational+ cx rat)
```

Arguments:

Name: cx

Type: <complex>

Description: A complex value

Name: rat

Type: <rational>

Description: A rational value

Result value: The sum of the arguments

Result type: <complex>

Purity of the procedure: pure

rational-complex+

Syntax:

```
(rational-complex+ rat cx)
```

Arguments:

Name: rat

Type: <rational>

Description: An rational value

Name: cx

Type: <complex>

Description: A complex value

Result value: The sum of the arguments

Result type: <complex>

Purity of the procedure: pure

complex-

Syntax:

```
(complex- cx1 cx2)
```

Arguments:

Name: cx1

Type: <complex>

Description: A complex value

Name: cx2

Type: <complex>

Description: A complex value

Result value: The difference of the arguments

Result type: <complex>

Purity of the procedure: pure

complex-integer-

Syntax:

```
(complex-integer- cx i)
```

Arguments:

Name: `cx`

Type: <complex>

Description: A complex value

Name: `i`

Type: <integer>

Description: An integer value

Result value: The difference of the arguments

Result type: <complex>

Purity of the procedure: pure

integer-complex-

Syntax:

```
(integer-complex- i cx)
```

Arguments:

Name: `i`

Type: <integer>

Description: An integer value

Name: `cx`

Type: <complex>

Description: A complex value

Result value: The difference of the arguments

Result type: <complex>

Purity of the procedure: pure

complex-real-

Syntax:

```
(complex-real- cx r)
```

Arguments:

Name: `cx`
Type: <complex>
Description: A complex value

Name: `r`
Type: <real>
Description: A real value

Result value: The difference of the arguments

Result type: <complex>

Purity of the procedure: pure

real-complex-

Syntax:

```
(real-complex- r cx)
```

Arguments:

Name: `r`
Type: <real>
Description: A real value

Name: `cx`
Type: <complex>
Description: A complex value

Result value: The difference of the arguments

Result type: <complex>

Purity of the procedure: pure

complex-rational-

Syntax:

```
(complex-rational- cx rat)
```

Arguments:

Name: `cx`
Type: `<complex>`
Description: A complex value

Name: `rat`
Type: `<rational>`
Description: A rational value

Result value: The difference of the arguments

Result type: `<complex>`

Purity of the procedure: pure

rational-complex-

Syntax:

```
(rational-complex- rat cx)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: An rational value

Name: `cx`
Type: `<complex>`
Description: A complex value

Result value: The difference of the arguments

Result type: `<complex>`

Purity of the procedure: pure

complex*

Syntax:

```
(complex* cx1 cx2)
```

Arguments:

Name: `cx1`
Type: `<complex>`
Description: A complex value

Name: `cx2`
Type: `<complex>`
Description: A complex value

Result value: The product of the arguments

Result type: `<complex>`

Purity of the procedure: pure

complex-integer*

Syntax:

```
(complex-integer* cx i)
```

Arguments:

Name: `cx`
Type: `<complex>`
Description: A complex value

Name: `i`
Type: `<integer>`
Description: An integer value

Result value: The product of the arguments

Result type: `<complex>`

Purity of the procedure: pure

integer-complex*

Syntax:

```
(integer-complex* i cx)
```

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer value

Name: `cx`
Type: `<complex>`
Description: A complex value

Result value: The product of the arguments

Result type: `<complex>`

Purity of the procedure: pure

complex-real*

Syntax:

```
(complex-real* cx r)
```

Arguments:

Name: `cx`
Type: `<complex>`
Description: A complex value

Name: `r`
Type: `<real>`
Description: A real value

Result value: The product of the arguments

Result type: `<complex>`

Purity of the procedure: pure

real-complex*

Syntax:

```
(real-complex* r cx)
```

Arguments:

Name: `r`
Type: `<real>`
Description: A real value

Name: `cx`
Type: `<complex>`
Description: A complex value

Result value: The product of the arguments

Result type: `<complex>`

Purity of the procedure: pure

`complex-rational*`

Syntax:

```
(complex-rational* cx rat)
```

Arguments:

Name: `cx`
Type: `<complex>`
Description: A complex value

Name: `rat`
Type: `<rational>`
Description: A rational value

Result value: The product of the arguments

Result type: `<complex>`

Purity of the procedure: pure

`rational-complex*`

Syntax:

(rational-complex* rat cx)

Arguments:

Name: rat
Type: <rational>
Description: An rational value

Name: cx
Type: <complex>
Description: A complex value

Result value: The product of the arguments

Result type: <complex>

Purity of the procedure: pure

complex/

Syntax:

(complex/ cx1 cx2)

Arguments:

Name: cx1
Type: <complex>
Description: A complex value

Name: cx2
Type: <complex>
Description: A complex value

Result value: The quotient of the arguments

Result type: <complex>

Purity of the procedure: pure

complex-integer/

Syntax:

(complex-integer/ cx i)

Arguments:

Name: `cx`
Type: `<complex>`
Description: A complex value

Name: `i`
Type: `<integer>`
Description: An integer value

Result value: The quotient of the arguments

Result type: `<complex>`

Purity of the procedure: pure

`integer-complex/`

Syntax:

```
(integer-complex/ i cx)
```

Arguments:

Name: `i`
Type: `<integer>`
Description: An integer value

Name: `cx`
Type: `<complex>`
Description: A complex value

Result value: The quotient of the arguments

Result type: `<complex>`

Purity of the procedure: pure

`complex-real/`

Syntax:

```
(complex-real/ cx r)
```

Arguments:

Name: `cx`
Type: `<complex>`
Description: A complex value

Name: `r`
Type: `<real>`
Description: A real value

Result value: The quotient of the arguments

Result type: `<complex>`

Purity of the procedure: pure

`real-complex/`

Syntax:

`(real-complex/ r cx)`

Arguments:

Name: `r`
Type: `<real>`
Description: A real value

Name: `cx`
Type: `<complex>`
Description: A complex value

Result value: The quotient of the arguments

Result type: `<complex>`

Purity of the procedure: pure

`complex-rational/`

Syntax:

`(complex-rational/ cx rat)`

Arguments:

Name: `cx`
Type: `<complex>`
Description: A complex value

Name: `rat`
Type: `<rational>`
Description: A rational value

Result value: The quotient of the arguments

Result type: `<complex>`

Purity of the procedure: pure

`rational-complex/`

Syntax:

```
(rational-complex/ rat cx)
```

Arguments:

Name: `rat`
Type: `<rational>`
Description: An rational value

Name: `cx`
Type: `<complex>`
Description: A complex value

Result value: The quotient of the arguments

Result type: `<complex>`

Purity of the procedure: pure

`c-neg`

Syntax:

```
(c-neg c)
```

Arguments:

Name: `c`

Type: `<complex>`
Description: A complex number

Result value: The opposite number of the given complex number
Result type: `<complex>`

Purity of the procedure: pure

c-abs

Syntax:

`(c-abs c)`

Arguments:

Name: `c`
Type: `<complex>`
Description: A complex number

Result value: The absolute value of the given complex number
Result type: `<real>`

Purity of the procedure: pure

c-square

Syntax:

`(c-square c)`

Arguments:

Name: `c`
Type: `<complex>`
Description: A complex number

Result value: The square of the given complex number
Result type: `<complex>`

Purity of the procedure: pure

real-part

Syntax:

```
(real-part c)
```

Arguments:

Name: c
Type: <complex>
Description: A complex number

Result value: The real part of the given complex number

Result type: <real>

Purity of the procedure: pure

imag-part

Syntax:

```
(imag-part c)
```

Arguments:

Name: c
Type: <complex>
Description: A complex number

Result value: The imaginary part of the given complex number

Result type: <real>

Purity of the procedure: pure

make-polar

Syntax:

```
(make-polar magnitude angle)
```

Arguments:

Name: magnitude

Type: `<real>`

Name: `angle`

Type: `<real>`

Result value: The complex number having the given magnitude and angle

Result type: `<complex>`

Purity of the procedure: pure

c-angle

Syntax:

`(c-angle c)`

Arguments:

Name: `c`

Type: `<complex>`

Description: A complex number

Result value: The angle of the given complex number

Result type: `<real>`

Purity of the procedure: pure

r-complex-log

Syntax:

`(r-complex-log r)`

Arguments:

Name: `r`

Type: `<real>`

Description: A real number

Result value: The natural logarithm of `r`

Result type: `<complex>`

Purity of the procedure: pure

The result is computed correctly for the negative values of r , too.

r-log-neg

Syntax:

`(r-log-neg r)`

Arguments:

Name: `r`
 Type: `<real>`
 Description: A negative real number

Result value: The natural logarithm of `r`

Result type: `<complex>`

Purity of the procedure: pure

The natural logarithm of a negative real number r is $\ln r = \ln |r| + i\pi$.

r-log10-neg

Syntax:

`(r-log10-neg r)`

Arguments:

Name: `r`
 Type: `<real>`
 Description: A negative real number

Result value: The base 10 logarithm of `r`

Result type: `<complex>`

Purity of the procedure: pure

The base 10 logarithm of a negative real number r is $\log_{10} r = \log_{10} |r| + i\pi / \ln 10$.

r-complex-expt

Syntax:

(**r-complex-expt** r-base r-exponent)

Arguments:

Name: **r-base**
Type: **<real>**
Description: A real number

Name: **r-exponent**
Type: **<real>**
Description: A real number

Result value: **r-base** raised to the power of **r-exponent**

Result type: **<complex>**

Purity of the procedure: pure

The result is computed correctly for the negative values of **r-base**, too.

complex-real-expt

Syntax:

(**complex-real-expt** cx-base r-exponent)

Arguments:

Name: **cx-base**
Type: **<complex>**
Description: A complex number

Name: **r-exponent**
Type: **<real>**
Description: A real number

Result value: **cx-base** raised to the power of **r-exponent**

Result type: **<complex>**

Purity of the procedure: pure

real-complex-expt

Syntax:

(real-complex-expt r-base cx-exponent)

Arguments:

Name: r-base
 Type: <real>
 Description: A real number

Name: cx-exponent
 Type: <complex>
 Description: A complex number

Result value: r-base raised to the power of cx-exponent

Result type: <complex>

Purity of the procedure: pure

This procedure works for negative values of r-base, too.

c-exp2

Syntax:

(c-exp2 cx)

Arguments:

Name: cx
 Type: <complex>
 Description: A complex number

Result value: 2 raised to the power of cx-exponent

Result type: <complex>

Purity of the procedure: pure

c-nonneg-int-expt

Syntax:

(c-nonneg-int-expt cx-base i-expt)

Arguments:

Name: `cx-base`
Type: `<complex>`
Description: A complex number

Name: `i-expt`
Type: `<integer>`
Description: A nonnegative integer number

Result value: `cx-base` raised to the power `i-expt`
Result type: `<complex>`

Purity of the procedure: pure

`c-int-expt`

Syntax:

`(c-int-expt cx-base i-expt)`

Arguments:

Name: `cx-base`
Type: `<complex>`
Description: A complex number

Name: `i-expt`
Type: `<integer>`
Description: An integer number

Result value: `cx-base` raised to the power `i-expt`
Result type: `<complex>`

Purity of the procedure: pure

`c-sqrt`

Syntax:

`(c-sqrt c)`

Arguments:

Name: `c`

Type: <complex>
Description: A complex number

Result value: Square root of the argument
Result type: <complex>

Purity of the procedure: pure

c-expt

Syntax:

(c-expt x y)

Arguments:

Name: x
Type: <complex>
Description: A complex number

Name: y
Type: <complex>
Description: A complex number

Result value: x to the power of y
Result type: <complex>

Purity of the procedure: pure

c-exp

Syntax:

(c-exp c)

Arguments:

Name: c
Type: <complex>
Description: A complex number

Result value: e to the power of r
Result type: <complex>

Purity of the procedure: pure

Number e is the base of natural logarithms (approx. 2.718).

c-log

Syntax:

(c-log c)

Arguments:

Name: c
Type: <complex>
Description: A complex number

Result value: The natural logarithm of r

Result type: <complex>

Purity of the procedure: pure

c-log10

Syntax:

(c-log10 c)

Arguments:

Name: c
Type: <complex>
Description: A complex number

Result value: The base 10 logarithm of r

Result type: <complex>

Purity of the procedure: pure

c-sin

Syntax:

`(c-sin c)`

Arguments:

Name: `c`
Type: `<complex>`
Description: A complex number

Result value: The sine of the argument

Result type: `<complex>`

Purity of the procedure: pure

C-COS

Syntax:

`(c-cos c)`

Arguments:

Name: `c`
Type: `<complex>`
Description: A complex number

Result value: The cosine of the argument

Result type: `<complex>`

Purity of the procedure: pure

c-tan

Syntax:

`(c-tan c)`

Arguments:

Name: `c`
Type: `<complex>`
Description: A complex number

Result value: The tangent of the argument

Result type: <complex>

Purity of the procedure: pure

c-asin

Syntax:

```
(c-asin c)
```

Arguments:

Name: `c`
Type: <complex>
Description: A complex number

Result value: The arcsine of the argument

Result type: <complex>

Purity of the procedure: pure

This procedure sometimes returns a value from a different branch compared to guile (2.2.2) `asin`. Our convention is similar to Octave (version 3.8.1).

c-acos

Syntax:

```
(c-acos c)
```

Arguments:

Name: `c`
Type: <complex>
Description: A complex number

Result value: The arccosine of the argument

Result type: <complex>

This procedure sometimes returns a value from a different branch compared to guile (2.2.2) `acos`. Our convention is similar to Octave (version 3.8.1).

Purity of the procedure: pure

c-atan*Syntax:*`(c-atan c)`*Arguments:*

Name: c
Type: <complex>
Description: A complex number

Result value: The arctangent of the argument*Result type:* <complex>*Purity of the procedure:* pure**c-sinh***Syntax:*`(c-sinh c)`*Arguments:*

Name: c
Type: <complex>
Description: A complex number

Result value: The hyperbolic sine of the argument*Result type:* <complex>*Purity of the procedure:* pure**c-cosh***Syntax:*`(c-cosh c)`*Arguments:*

Name: c

Type: `<complex>`
Description: A complex number

Result value: The hyperbolic cosine of the argument
Result type: `<complex>`

Purity of the procedure: pure

`c-tanh`

Syntax:

`(c-tanh c)`

Arguments:

Name: `c`
Type: `<complex>`
Description: A complex number

Result value: The hyperbolic tangent of the argument
Result type: `<complex>`

Purity of the procedure: pure

`c-asinh`

Syntax:

`(c-asinh c)`

Arguments:

Name: `c`
Type: `<complex>`
Description: A complex number

Result value: The hyperbolic arcsine of the argument
Result type: `<complex>`

Purity of the procedure: pure

c-acosh

Syntax:

```
(c-acosh c)
```

Arguments:

Name: c
Type: <complex>
Description: A complex number

Result value: The hyperbolic arccosine of the argument

Result type: <complex>

Purity of the procedure: pure

c-atanh

Syntax:

```
(c-atanh c)
```

Arguments:

Name: c
Type: <complex>
Description: A complex number

Result value: The hyperbolic arctangent of the argument

Result type: <complex>

Purity of the procedure: pure

This procedure sometimes returns a value from a different branch compared to guile (2.2.2) `atanh`. Our convention is similar to Octave (version 3.8.1).

complex-to-string

Syntax:

```
(complex-to-string c)
```

Arguments:

Name: `c`
 Type: `<complex>`
 Description: A complex number

Result value: The complex number as a string

Result type: `<string>`

Purity of the procedure: pure

16.3 Methods

```
complex: (<real-number> <real-number>) → <complex>   pure abstract
complex: (<real> <real>) → <complex> pure
complex: (<real> <integer>) → <complex> pure
complex: (<real> <rational>) → <complex> pure
complex: (<integer> <real>) → <complex> pure
complex: (<integer> <integer>) → <complex> pure
complex: (<integer> <rational>) → <complex> pure
complex: (<rational> <real>) → <complex> pure
complex: (<rational> <integer>) → <complex> pure
complex: (<rational> <rational>) → <complex> pure
```

These methods construct a complex number from the real and imaginary parts given as arguments. The arguments are converted to `<real>` if necessary.

```
equal?: (<complex> <complex>) → <boolean> pure   =   complex=?
equal?: (<complex> <integer>) → <boolean> pure   =   complex-integer=?
equal?: (<integer> <complex>) → <boolean> pure   =   integer-complex=?
equal?: (<complex> <real>) → <boolean> pure     =   complex-real=?
equal?: (<real> <complex>) → <boolean> pure     =   real-complex=?
equal?: (<complex> <rational>) → <boolean> pure  =   complex-rational=?
equal?: (<rational> <complex>) → <boolean> pure  =   rational-complex=?

+: (<complex> <complex>) → <complex> pure   =   complex+
+: (<complex> <integer>) → <complex> pure   =   complex-integer+
+: (<integer> <complex>) → <complex> pure   =   integer-complex+
+: (<complex> <real>) → <complex> pure     =   complex-real+
+: (<real> <complex>) → <complex> pure     =   real-complex+
+: (<complex> <rational>) → <complex> pure  =   complex-rational+
+: (<rational> <complex>) → <complex> pure  =   rational-complex+

-: (<complex> <complex>) → <complex> pure   =   complex-
-: (<complex> <integer>) → <complex> pure   =   complex-integer-
-: (<integer> <complex>) → <complex> pure   =   integer-complex-
-: (<complex> <real>) → <complex> pure     =   complex-real-
-: (<real> <complex>) → <complex> pure     =   real-complex-
-: (<complex> <rational>) → <complex> pure  =   complex-rational-
```



```

-: (<rational> <complex>) → <complex> pure = rational-complex-

*: (<complex> <complex>) → <complex> pure = complex*
*: (<complex> <integer>) → <complex> pure = complex-integer*
*: (<integer> <complex>) → <complex> pure = integer-complex*
*: (<complex> <real>) → <complex> pure = complex-real*
*: (<real> <complex>) → <complex> pure = real-complex*
*: (<complex> <rational>) → <complex> pure = complex-rational*
*: (<rational> <complex>) → <complex> pure = rational-complex*

/: (<complex> <complex>) → <complex> pure = complex/
/: (<complex> <integer>) → <complex> pure = complex-integer/
/: (<integer> <complex>) → <complex> pure = integer-complex/
/: (<complex> <real>) → <complex> pure = complex-real/
/: (<real> <complex>) → <complex> pure = real-complex/
/: (<complex> <rational>) → <complex> pure = complex-rational/
/: (<rational> <complex>) → <complex> pure = rational-complex/

-: (<complex>) → <complex> pure = c-neg
square: (<complex>) → <complex> pure = c-square
abs: (<complex>) → <real> pure = c-abs

atom-to-string: (<complex> <boolean>) → <string> pure = complex-to-string

```


Chapter 17

Module (standard-library math)

This module reexports modules `rational`, `real-math`, and `complex`.

17.1 Data Types

Data type name: `<number>`

Type: `:union`

Description: A number

Type `<number>` is equal to the union of `<complex>`, `<real>`, `<rational>`, and `<integer>`.

17.2 Simple Procedures

`integer-valued?`

Syntax:

```
(integer-valued? x)
```

Arguments:

Name: `x`

Type: `<object>`

Description: An object

Result value: `#t` iff the argument is integer valued

Result type: `<boolean>`

Purity of the procedure: pure

An object is integer valued if one of the following holds:

- It is an `<integer>`
- It is an integer valued `<rational>`
- It is an integer valued `<real>`
- It is a `<complex>` whose imaginary part is 0.0 and real part is integer valued

real-valued?

Syntax:

```
(real-valued? x)
```

Arguments:

Name: `x`
Type: `<object>`
Description: An object

Result value: `#t` iff the argument is real valued

Result type: `<boolean>`

Purity of the procedure: pure

An object is real valued if

- It is an `<integer>`,
- It is a `<rational>`,
- It is a `<real>`, or
- It is a `<complex>` whose imaginary part is 0.0

rational-valued?

Syntax:

```
(rational-valued? x)
```

Arguments:

Name: `x`
Type: `<object>`
Description: An object

Result value: `#t` iff the argument is rational valued

Result type: `<boolean>`

Purity of the procedure: pure

An object is rational valued if

- It is an `<integer>`,
- It is a `<rational>`,
- It is an integer valued `<real>`, or
- It is a `<complex>` whose imaginary part is 0.0 and real part is integer valued

`exact?`

Syntax:

`(exact? nr)`

Arguments:

Name: `nr`
Type: `<number>`
Description: A number

Result value: `#t` iff the argument is exact

Result type: `<boolean>`

Purity of the procedure: pure

A number is exact iff it is an `<integer>` or a `<rational>`.

`inexact?`

Syntax:

`(inexact? nr)`

Arguments:

Name: `nr`
 Type: `<number>`
 Description: A number

Result value: `#t` iff the argument is inexact

Result type: `<boolean>`

Purity of the procedure: pure

A number is exact iff it is not inexact, i.e, it is an `<real>` or a `<complex>`.

`real->exact`

Syntax:

`(real->exact r)`

Arguments:

Name: `r`
 Type: `<real>`
 Description: A real number

Result value: The argument converted to a rational or an integer

Result type: `<rational-number>`

Purity of the procedure: pure

`complex->exact`

Syntax:

`(complex->exact cx)`

Arguments:

Name: `cx`
 Type: `<complex>`
 Description: A complex number

Result value: The argument converted to a rational or an integer

Result type: `<rational-number>`

Purity of the procedure: pure

real->exact

Syntax:

```
(real->exact r)
```

Arguments:

Name: r
 Type: <real>
 Description: A real number

Result value: The argument converted to a rational or an integer

Result type: <rational-number>

Purity of the procedure: pure

If the imaginary part of the argument is not 0.0 exception `complex->exact:invalid-argument` is raised.

17.3 Methods

```
exact->inexact: (<number>) → <number> pure abstract
exact->inexact: (<real-number>) → <real-number> pure abstract
exact->inexact: (<integer>) → <real> pure = integer->real
exact->inexact: (<rational>) → <real> pure = rational->real
```

```
exact->inexact: (<real>) → <real> pure
```

Returns the argument.

```
exact->inexact: (<complex>) → <complex> pure
```

Returns the argument.

```
inexact->exact: (<number>) → <rational-number> pure abstract
inexact->exact: (<complex>) → <rational-number> pure = complex->exact
inexact->exact: (<real>) → <rational-number> pure = real->exact
```

```
inexact->exact: (<rational>) → <rational> pure
```

Returns the argument.

`inexact->exact: (<integer>) → <integer> pure`

Returns the argument.

`+: (<number> <number>) → <number> pure abstract`
`-: (<number> <number>) → <number> pure abstract`
`*: (<number> <number>) → <number> pure abstract`
`/: (<number> <number>) → <number> pure abstract`

`-: (<number>) → <number> pure abstract`
`abs: (<number>) → <real-number> pure abstract`
`square: (<number>) → <number> pure abstract`

`sqrt: (<number>) → <number> pure abstract`
`sqrt: (<integer>) → <number> pure`
`sqrt: (<rational>) → <number> pure`
`sqrt: (<real>) → (:union <real> <complex>) pure`
`sqrt: (<complex>) → <complex> pure = c-sqrt`

These methods compute the square root of the argument. They return exact 0 when the argument is exact 0.

`expt: (<number> <number>) → <number> pure abstract`
`expt: (<integer> <integer>) → <rational-number> pure`
`expt: (<integer> <real>) → (:union <real> <complex>) pure`
`expt: (<integer> <rational>) → <number> pure`
`expt: (<integer> <complex>) → <complex> pure`
`expt: (<real> <integer>) → (:union <real> <integer>) pure`
`expt: (<real> <real>) → (:union <real> <complex>) pure`
`expt: (<real> <rational>) → (:union <integer> <real> <complex>) pure`
`expt: (<real> <complex>) → <complex> pure`
`expt: (<rational> <integer>) → <rational> pure = rat-int-expt`
`expt: (<rational> <real>) → (:union <integer> <real> <complex>) pure`
`expt: (<rational> <rational>) → <number> pure`
`expt: (<rational> <complex>) → <complex> pure`
`expt: (<complex> <integer>) → (:union <complex> <integer>) pure`
`expt: (<complex> <real>) → <complex> pure`
`expt: (<complex> <rational>) → <complex> pure`
`expt: (<complex> <complex>) → <complex> pure = c-expt`

These methods raise the first argument to the power of the second argument. If any of the arguments is equal to exact 0 the value 0 or 1 is returned in many cases.

`exp: (<number>) → <number> pure abstract`
`exp: (<real-number>) → (:union <real> <integer>) pure abstract`
`exp: (<integer>) → (:union <real> <integer>) pure`
`exp: (<rational>) → (:union <real> <integer>) pure`
`exp: (<real>) → <real> pure = r-exp`
`exp: (<complex>) → <complex> pure = c-exp`

These methods compute the exponential of the argument. They return exact 1 when the argument is exact 0.

```
log: (<number>) → <number> pure abstract
log: (<integer>) → (:union <integer> <real> <complex>) pure
log: (<rational>) → (:union <integer> <real> <complex>) pure
log: (<real>) → (:union <real> <complex>) pure
log: (<complex>) → <complex> pure = c-log
```

These methods compute the natural logarithm of the argument. They return exact 0 when the argument is exact 1.

```
log10: (<number>) → <number> pure abstract
log10: (<integer>) → (:union <integer> <real> <complex>) pure
log10: (<rational>) → (:union <integer> <real> <complex>) pure
log10: (<real>) → (:union <real> <complex>) pure
log10: (<complex>) → <complex> pure = c-log10
```

These methods compute the logarithm with base 10 of the argument. They return exact 0 when the argument is exact 1.

```
sin: (<number>) → <number> pure abstract
sin: (<real-number>) → (:union <real> <integer>) pure abstract
sin: (<integer>) → (:union <real> <integer>) pure
sin: (<rational>) → (:union <real> <integer>) pure
sin: (<real>) → <real> pure = r-sin
sin: (<complex>) → <complex> pure = c-sin
```

These methods compute the sine of the argument. They return exact 0 when the argument is exact 0.

```
cos: (<number>) → <number> pure abstract
cos: (<real-number>) → (:union <real> <integer>) pure abstract
cos: (<integer>) → (:union <real> <integer>) pure
cos: (<rational>) → (:union <real> <integer>) pure
cos: (<real>) → <real> pure = r-cos
cos: (<complex>) → <complex> pure = c-cos
```

These methods compute the cosine of the argument. They return exact 1 when the argument is exact 0.

```
tan: (<number>) → <number> pure abstract
tan: (<real-number>) → (:union <real> <integer>) pure abstract
tan: (<integer>) → (:union <real> <integer>) pure
tan: (<rational>) → (:union <real> <integer>) pure
tan: (<real>) → <real> pure = r-tan
tan: (<complex>) → <complex> pure = c-tan
```

These methods compute the tangent of the argument. They return exact 0 when the argument is exact 0.

```

asin: (<number>) → <number>   pure abstract
asin: (<integer>) → (:union <integer> <real> <complex>) pure
asin: (<rational>) → (:union <integer> <real> <complex>) pure
asin: (<real>) → (:union <real> <complex>) pure
asin: (<complex>) → <complex> pure   =   c-asin

```

These methods compute the arcsine of the argument. They return exact 0 when the argument is exact 0. See the note for `c-asin`, which may also apply when the argument is real.

```

acos: (<number>) → <number>   pure abstract
acos: (<integer>) → (:union <integer> <real> <complex>) pure
acos: (<rational>) → (:union <integer> <real> <complex>) pure
acos: (<real>) → (:union <real> <complex>) pure
acos: (<complex>) → <complex> pure   =   c-acos

```

These methods compute the arccosine of the argument. They return exact 0 when the argument is exact 1. See the note for `c-acos`, which may also apply when the argument is real.

```

atan: (<number>) → <number>   pure abstract
atan: (<real-number>) → <real-number>   pure abstract
atan: (<integer>) → (:union <real> <integer>) pure
atan: (<rational>) → (:union <real> <integer>) pure
atan: (<real>) → <real> pure   =   r-atan
atan: (<complex>) → <complex> pure   =   c-atan

```

These methods compute the arctangent of the argument. They return exact 0 when the argument is exact 0.

```

sinh: (<number>) → <number>   pure abstract
sinh: (<real-number>) → (:union <real> <integer>)   pure abstract
sinh: (<integer>) → (:union <real> <integer>) pure
sinh: (<rational>) → (:union <real> <integer>) pure
sinh: (<real>) → <real> pure   =   r-sinh
sinh: (<complex>) → <complex> pure   =   c-sinh

```

These methods compute the hyperbolic sine of the argument. They return exact 0 when the argument is exact 0.

```

cosh: (<number>) → <number>   pure abstract
cosh: (<real-number>) → (:union <real> <integer>)   pure abstract
cosh: (<integer>) → (:union <real> <integer>) pure
cosh: (<rational>) → (:union <real> <integer>) pure
cosh: (<real>) → <real> pure   =   r-cosh
cosh: (<complex>) → <complex> pure   =   c-cosh

```

These methods compute the hyperbolic cosine of the argument. They return exact 1 when the argument is exact 0.

```

tanh: (<number>) → <number>   pure abstract

```

```

tanh: (<real-number>) → (:union <real> <integer>) pure abstract
tanh: (<integer>) → (:union <real> <integer>) pure
tanh: (<rational>) → (:union <real> <integer>) pure
tanh: (<real>) → <real> pure = r-tanh
tanh: (<complex>) → <complex> pure = c-tanh

```

These methods compute the hyperbolic tangent of the argument. They return exact 0 when the argument is exact 0.

```

asinh: (<number>) → <number> pure abstract
asinh: (<real-number>) → (:union <real> <integer>) pure abstract
asinh: (<integer>) → (:union <real> <integer>) pure
asinh: (<rational>) → (:union <real> <integer>) pure
asinh: (<real>) → <real> pure = r-asinh
asinh: (<complex>) → <complex> pure = c-asinh

```

These methods compute the inverse hyperbolic sine of the argument. They return exact 0 when the argument is exact 0.

```

acosh: (<number>) → <number> pure abstract
acosh: (<integer>) → (:union <integer> <real> <complex>) pure
acosh: (<rational>) → (:union <integer> <real> <complex>) pure
acosh: (<real>) → (:union <real> <complex>) pure
acosh: (<complex>) → <complex> pure = c-acosh

```

These methods compute the inverse hyperbolic cosine of the argument. They return exact 0 when the argument is exact 1.

```

atanh: (<number>) → <number> pure abstract
atanh: (<integer>) → (:union <integer> <real> <complex>) pure
atanh: (<rational>) → (:union <integer> <real> <complex>) pure
atanh: (<real>) → (:union <real> <complex>) pure
atanh: (<complex>) → <complex> pure = c-atanh

```

These methods compute the inverse hyperbolic tangent of the argument. They return exact 0 when the argument is exact 0. See the note for `c-atanh`, which may also apply when the argument is real.

Chapter 18

Module (standard-library extra-math)

This module implements wrapper procedures to many of the mathematical functions in standard C. Additionally, some helper procedures and methods are defined.

18.1 Wrapper Procedures for Standard C Functions

The following procedures are wrappers to the corresponding functions in the standard C (without the prefix “r-”):

```
fmod: (<real> <real>) → <real> pure
r-remainder: (<real> <real>) → <real> pure
r-fma: (<real> <real> <real>) → <real> pure
fmin: (<real> <real>) → <real> pure
fmax: (<real> <real>) → <real> pure
fdim: (<real> <real>) → <real> pure
r-exp2: (<real>) → <real> pure
r-expm1: (<real>) → <real> pure
r-log2: (<real>) → <real> pure
r-log1p: (<real>) → <real> pure
logb: (<real>) → <real> pure
ilogb: (<real>) → <integer> pure
r-cbrt: (<real>) → <real> pure
r-hypot: (<real> <real>) → <real> pure
r-erf: (<real>) → <real> pure
r-erfc: (<real>) → <real> pure
r-lgamma: (<real>) → <real> pure
r-tgamma: (<real>) → <real> pure
r-nearbyint: (<real>) → <real> pure
rint: (<real>) → <real> pure
frexp: (<real>) → (:pair <real> <integer>) pure
ldexp: (<real> <integer>) → <real> pure
```

```

modf: (<real>) → (:pair <real> <real>) pure
r-nextafter: (<real> <real>) → <real> pure
r-copysign: (<real> <real>) → <real> pure
fpclassify: (<real>) → <integer> pure
r-isnormal?: (<real>) → <boolean> pure
r-signbit: (<real>) → <integer> pure

```

Procedure `frexp` returns the fraction of its argument in the head of the result and the exponent in the tail. Procedure `modf` returns the fractional part of its argument in the head of the result and the integer part in the tail. There are no wrappers for `isinf` and `isnan` since similar functions are defined in the core module. See e.g.

https://en.wikipedia.org/wiki/C_mathematical_functions

and the GNU libc Reference for further documentation.

18.2 Other Simple Procedures

r-log2-neg

Syntax:

```
(r-log2-neg r)
```

Arguments:

Name: `r`
 Type: `<real>`
 Description: A negative real number

Result value: The base 2 logarithm of `r`

Result type: `<complex>`

Purity of the procedure: pure

The base 2 logarithm of a negative real number r is $\log_2 r = \log_2 |r| + i\pi / \ln 2$.

i-cbrt

Syntax:

```
(i-cbrt i)
```

Arguments:

Name: i
 Type: <integer>
 Description: An integer number

Result value: The cubic root of the argument

Result type: (:union <real> <integer>)

Purity of the procedure: pure

It seems that this procedure can't always detect integer valued results because of floating point errors.

rat-cbrt

Syntax:

```
(rat-cbrt rat)
```

Arguments:

Name: rat
 Type: <rational>
 Description: A rational number

Result value: The cubic root of the argument

Result type: (:union <real> <rational> <integer>)

Purity of the procedure: pure

It seems that this procedure can't always detect integer or rational valued results because of floating point errors.

18.3 Methods

```
exp2: (<number>) → <number> pure abstract
exp2: (<real-number>) → <real-number> pure abstract
exp2: (<complex>) → <complex> pure
exp2: (<real>) → <real> pure = r-exp2
exp2: (<rational>) → <real-number> pure
exp2: (<integer>) → <rational-number> pure
```

These methods compute 2^x .

```
expm1: (<number>) → <number> pure abstract
expm1: (<real-number>) → <real-number> pure abstract
expm1: (<complex>) → <complex> pure
```

```

expm1: (<real>) → <real> pure    =    r-expm1
expm1: (<rational>) → (:union <real> <integer>) pure
expm1: (<integer>) → (:union <real> <integer>) pure

```

These methods compute $\exp x - 1$.

```

log2: (<number>) → <number>   pure abstract
log2: (<complex>) → <complex> pure
log2: (<real>) → (:union <real> <complex>) pure
log2: (<rational>) → (:union <integer> <real> <complex>) pure
log2: (<integer>) → (:union <integer> <real> <complex>) pure

```

These methods compute $\log_2 x$.

```

log1p: (<number>) → <number>   pure abstract
log1p: (<complex>) → <complex> pure
log1p: (<real>) → (:union <complex> <real>) pure
log1p: (<rational>) → (:union <complex> <real> <integer>) pure
log1p: (<integer>) → (:union <complex> <real> <integer>) pure

```

These methods compute $\ln(1 + x)$.

```

cbirt: (<number>) → <number>   pure abstract
cbirt: (<real-number>) → <real-number>   pure abstract
cbirt: (<complex>) → <complex> pure
cbirt: (<real>) → <real> pure    =    r-cbirt
cbirt: (<rational>) → (:union <real> <rational> <integer>) pure
cbirt: (<integer>) → (:union <real> <integer>) pure

```

These methods compute the cubic root of x . They are defined for negative arguments, too.

```

hypot: (<real-number> <real-number>) → <real-number>   pure abstract
hypot: (<real> <real>) → <real> pure    =    r-hypot
hypot: (<real> <rational>) → <real> pure
hypot: (<real> <integer>) → <real> pure
hypot: (<rational> <real>) → <real> pure
hypot: (<rational> <rational>) → <real-number> pure
hypot: (<rational> <integer>) → <real-number> pure
hypot: (<integer> <real>) → <real> pure
hypot: (<integer> <rational>) → <real-number> pure
hypot: (<integer> <integer>) → (:union <real> <integer>) pure

```

These methods compute $\sqrt{x^2 + y^2}$.

```

erf: (<real-number>) → (:union <real> <integer>)   pure abstract
erf: (<real>) → <real> pure    =    r-erf
erf: (<rational>) → (:union <real> <integer>) pure
erf: (<integer>) → (:union <real> <integer>) pure

```

These methods compute $\operatorname{erf} x$ (the error function).


```

erfc: (<real-number>) → (:union <real> <integer>) pure abstract
erfc: (<real>) → <real> pure = r-erfc
erfc: (<rational>) → (:union <real> <integer>) pure
erfc: (<integer>) → (:union <real> <integer>) pure

```

These methods compute $\operatorname{erfc} x = 1 - \operatorname{erf} x$ (the complementary error function).

```

lgamma: (<real-number>) → (:union <real> <integer>) pure abstract
lgamma: (<real>) → <real> pure = r-lgamma
lgamma: (<rational>) → (:union <real> <integer>) pure
lgamma: (<integer>)) → (:union <real> <integer>) pure

```

These methods compute $\ln |\Gamma(x)|$.

```

tgamma: (<real-number>) → (:union <real> <integer>) pure abstract
tgamma: (<real>) → <real> pure = r-tgamma
tgamma: (<rational>) → (:union <real> <integer>) pure
tgamma: (<integer>)) → (:union <real> <integer>) pure

```

These methods compute $\Gamma(x)$ (the gamma function). For positive integers the exact value is computed as a factorial.

Chapter 19

Module (standard-library posix-math)

This module implements wrapper procedures to many of the mathematical functions in POSIX C not belonging to the C standard. Additionally, some methods are defined.

See e.g.

https://en.wikipedia.org/wiki/C_POSIX_library

and the GNU libc Reference for further documentation.

19.1 Wrapper Procedures for POSIX C Functions

r-j0: (<real>) → <real> pure
r-j1: (<real>) → <real> pure
r-jn: (<integer> <real>) → <real> pure

r-y0: (<real>) → <real> pure
r-y1: (<real>) → <real> pure
r-yn: (<integer> <real>) → <real> pure

19.2 Methods

j0: (<real-number>) → <real> pure abstract
j0: (<real>) → <real> pure = r-j0
j0: (<rational>) → <real> pure
j0: (<integer>) → <real> pure

These methods compute the Bessel function j0.

```

j1: (<real-number>) → <real>  pure abstract
j1: (<real>) → <real> pure    =    r-j1
j1: (<rational>) → <real> pure
j1: (<integer>) → <real> pure

```

These methods compute the Bessel function `j1`.

```

jn: (<integer> <real-number>) → <real>  pure abstract
jn: (<integer> <real>) → <real> pure    =    r-jn
jn: (<integer> <rational>) → <real> pure
jn: (<integer> <integer>) → <real> pure

```

These methods compute the Bessel functions `jn`.

```

y0: (<real-number>) → <real>  pure abstract
y0: (<real>) → <real> pure    =    r-y0
y0: (<rational>) → <real> pure
y0: (<integer>) → <real> pure

```

These methods compute the Bessel function `y0`.

```

y1: (<real-number>) → <real>  pure abstract
y1: (<real>) → <real> pure    =    r-y1
y1: (<rational>) → <real> pure
y1: (<integer>) → <real> pure

```

These methods compute the Bessel function `y1`.

```

yn: (<integer> <real-number>) → <real>  pure abstract
yn: (<integer> <real>) → <real> pure    =    r-yn
yn: (<integer> <rational>) → <real> pure
yn: (<integer> <integer>) → <real> pure

```

These methods compute the Bessel functions `yn`.

Chapter 20

Module (standard-library matrix)

20.1 Data Types

Data type name: `:matrix`

Type: `<param-class>`

Number of type parameters: 1

Description: A complex number

Data type name: `:diagonal-matrix`

Type: `<param-class>`

Number of type parameters: 1

Description: A complex number

Class `<complex>` is equal by value, not inheritable, and not immutable. Note that the indices of the matrices have base zero.

20.2 Parametrized Procedures

`column-vector`

Syntax:

`(column-vector lst)`

Type parameters: `%number`

Arguments:

Name: `lst`

Type: (:uniform-list %number)
Description: The contents of the vector

Result value: A column vector constructed from the argument list
Result type: (:matrix %number)

Purity of the procedure: pure

diagonal-matrix

Syntax:

```
(diagonal-matrix lst)
```

Type parameters: %number

Arguments:

Name: `lst`
Type: (:uniform-list %number)
Description: The contents of the diagonal

Result value: A diagonal matrix constructed from the argument list
Result type: (:diagonal-matrix %number)

Purity of the procedure: pure

diagonal-matrix*

Syntax:

```
(diagonal-matrix* mx1 mx2)
```

Type parameters: %number

Arguments:

Name: `mx1`
Type: (:diagonal-matrix %number)
Description: A diagonal matrix

Name: `mx2`
Type: (:diagonal-matrix %number)

Description: A diagonal matrix

Result value: Product of the given diagonal matrices

Result type: (:diagonal-matrix %number)

Purity of the procedure: pure

diagonal-matrix+

Syntax:

```
(diagonal-matrix+ mx1 mx2)
```

Type parameters: %number

Arguments:

Name: mx1

Type: (:diagonal-matrix %number)

Description: A diagonal matrix

Name: mx2

Type: (:diagonal-matrix %number)

Description: A diagonal matrix

Result value: Sum of the given diagonal matrices

Result type: (:diagonal-matrix %number)

Purity of the procedure: pure

diagonal-matrix-

Syntax:

```
(diagonal-matrix- mx1 mx2)
```

Type parameters: %number

Arguments:

Name: mx1

Type: (:diagonal-matrix %number)

Description: A diagonal matrix

Name: `mx2`
 Type: `(:diagonal-matrix %number)`
 Description: A diagonal matrix

Result value: Difference of the given diagonal matrices

Result type: `(:diagonal-matrix %number)`

Purity of the procedure: pure

diagonal-matrix-copy

Syntax:

```
(diagonal-matrix-copy mx)
```

Type parameters: `%number`

Arguments:

Name: `mx`
 Type: `(:diagonal-matrix %number)`
 Description: A diagonal matrix

Result value: A copy of the given diagonal matrix

Result type: `(:diagonal-matrix %number)`

Purity of the procedure: pure

The contents of the argument and result matrices will be different objects.

diagonal-matrix-ref

Syntax:

```
(diagonal-matrix-ref mx index)
```

Type parameters: `%number`

Arguments:

Name: `mx`
 Type: `(:diagonal-matrix %number)`
 Description: A diagonal matrix

Name: `index`
Type: `<integer>`
Description: Index to the element

Result value: An element of the diagonal matrix

Result type: `%number`

Purity of the procedure: pure

`diagonal-matrix-set!`

Syntax:

```
(diagonal-matrix-set! mx index value)
```

Type parameters: `%number`

Arguments:

Name: `mx`
Type: `(:diagonal-matrix %number)`
Description: A diagonal matrix

Name: `index`
Type: `<integer>`
Description: Index to the element

Name: `value`
Type: `%number`
Description: The new value of the element

No result value.

Purity of the procedure: nonpure

`make-column-vector`

Syntax:

```
(make-column-vector len element-value)
```

Type parameters: `%number`

Arguments:

Name: `len`
Type: `<integer>`
Description: The length of the vector

Name: `element-value`
Type: `%number`
Description: A value to fill the vector

Result value: A column vector
Result type: `(:matrix %number)`

Purity of the procedure: pure

make-diagonal-matrix*Syntax:*

```
(make-diagonal-matrix len element-value)
```

Type parameters: `%number`

Arguments:

Name: `len`
Type: `<integer>`
Description: The number of rows and columns in the diagonal matrix

Name: `element-value`
Type: `%number`
Description: A value to fill the diagonal

Result value: A diagonal matrix
Result type: `(:diagonal-matrix %number)`

Purity of the procedure: pure

make-matrix*Syntax:*

```
(make-matrix rows columns element-value)
```

Type parameters: %number

Arguments:

Name: `rows`
Type: `<integer>`
Description: Number of rows in the matrix

Name: `columns`
Type: `<integer>`
Description: Number of columns in the matrix

Name: `element-value`
Type: %number
Description: A value to fill the matrix

Result value: A matrix

Result type: `(:matrix %number)`

Purity of the procedure: pure

`make-row-vector`

Syntax:

```
(make-row-vector len element-value)
```

Type parameters: %number

Arguments:

Name: `len`
Type: `<integer>`
Description: The length of the vector

Name: `element-value`
Type: %number
Description: A value to fill the vector

Result value: A row vector

Result type: `(:matrix %number)`

Purity of the procedure: pure

matrix

Syntax:

```
(matrix lst)
```

Type parameters: %number

Arguments:

Name: `lst`
Type: `(:uniform-list (:uniform-list %number))`
Description: The contents of the matrix

Result value: A matrix constructed from the argument list

Result type: `(:matrix %number)`

Purity of the procedure: pure

The argument type shall be a list of number lists. Each sublist gives the contents of one row in the matrix. All of the sublists must have equal lengths.

matrix*

Syntax:

```
(matrix* mx1 mx2)
```

Type parameters: %number

Arguments:

Name: `mx1`
Type: `(:matrix %number)`
Description: A matrix

Name: `mx2`
Type: `(:matrix %number)`
Description: A matrix

Result value: Product of the given matrices

Result type: `(:matrix %number)`

Purity of the procedure: pure

matrix+

Syntax:

```
(matrix+ mx1 mx2)
```

Type parameters: %number

Arguments:

Name: mx1
Type: (:matrix %number)
Description: A matrix

Name: mx2
Type: (:matrix %number)
Description: A matrix

Result value: Sum of the given matrices

Result type: (:matrix %number)

Purity of the procedure: pure

matrix-

Syntax:

```
(matrix- mx1 mx2)
```

Type parameters: %number

Arguments:

Name: mx1
Type: (:matrix %number)
Description: A matrix

Name: mx2
Type: (:matrix %number)
Description: A matrix

Result value: Difference of the given matrices

Result type: (:matrix %number)

Purity of the procedure: pure

matrix-copy

Syntax:

```
(matrix-copy mx)
```

Type parameters: %number

Arguments:

Name: mx
Type: (:matrix %number)
Description: A matrix

Result value: A copy of the given matrix

Result type: (:matrix %number)

Purity of the procedure: pure

The contents of the argument and result matrices will be different objects.

row-vector

Syntax:

```
(row-vector lst)
```

Type parameters: %number

Arguments:

Name: lst
Type: (:uniform-list %number)
Description: The contents of the vector

Result value: A row vector constructed from the argument list

Result type: (:matrix %number)

Purity of the procedure: pure

20.3 Parametrized Methods

*

Syntax:

```
(* mx1 mx2)
```

Type parameters: %number

Arguments:

Name: mx1
Type: (:matrix %number) or (:diagonal-matrix %number)
Description: A matrix

Name: mx2
Type: (:matrix %number) or (:diagonal-matrix %number)
Description: A matrix

Result value: The product of the matrices

Result type: %number

Purity of the procedure: pure

All combinations of (:matrix %number) and (:diagonal-matrix %number) as argument types are supported.

*

Syntax:

```
(* nr mx)
```

Type parameters: %number

Arguments:

Name: nr
Type: %number
Description: A scalar

Name: mx
Type: (:matrix %number) or (:diagonal-matrix %number)

Description: A matrix

Result value: The product of the number and the matrix

Result type: (:matrix %number) or (:diagonal-matrix %number)

Purity of the procedure: pure

The result type is the same as the type of argument `mx`.

Syntax:

(`* mx nr`)

Type parameters: %number

Arguments:

Name: `mx`

Type: (:matrix %number) or (:diagonal-matrix %number)

Description: A matrix

Name: `nr`

Type: %number

Description: A scalar

Result value: The product of the matrix and the number

Result type: (:matrix %number) or (:diagonal-matrix %number)

Purity of the procedure: pure

The result type is the same as the type of argument `mx`.

/

Syntax:

(`/ mx nr`)

Type parameters: %number

Arguments:

Name: `mx`

Type: (:matrix %number) or (:diagonal-matrix %number)
 Description: A matrix

Name: nr
 Type: %number
 Description: A scalar

Result value: The quotient of the matrix and the number

Result type: (:matrix %number) or (:diagonal-matrix %number)

Purity of the procedure: pure

The result type is the same as the type of argument mx.

+

Syntax:

(+ mx1 mx2)

Type parameters: %number

Arguments:

Name: mx1
 Type: (:matrix %number) or (:diagonal-matrix %number)
 Description: A matrix

Name: mx2
 Type: (:matrix %number) or (:diagonal-matrix %number)
 Description: A matrix

Result value: The sum of the matrices

Result type: %number

Purity of the procedure: pure

All combinations of (:matrix %number) and (:diagonal-matrix %number) as argument types are supported.

-

Syntax:

(- mx)

Type parameters: %number

Arguments:

Name: mx
Type: (:matrix %number) or (:diagonal-matrix %number)
Description: A matrix

Result value: The opposite matrix

Result type: %number

Purity of the procedure: pure

The result type is the same as the type of argument mx.

—

Syntax:

(- mx1 mx2)

Type parameters: %number

Arguments:

Name: mx1
Type: (:matrix %number) or (:diagonal-matrix %number)
Description: A matrix

Name: mx2
Type: (:matrix %number) or (:diagonal-matrix %number)
Description: A matrix

Result value: The difference of the matrices

Result type: %number

Purity of the procedure: pure

All combinations of (:matrix %number) and (:diagonal-matrix %number) as argument types are supported.

matrix-ref

Syntax:

```
(matrix-ref mx row column)
```

Type parameters: %number

Arguments:

Name: mx
Type: (:matrix %number)
Description: A matrix

Name: row
Type: <integer>
Description: Row index

Name: column
Type: <integer>
Description: Column index

Result value: The element of the matrix at the given position

Result type: %number

Purity of the procedure: pure

matrix-ref

Syntax:

```
(matrix-ref mx row column)
```

Type parameters: %number

Arguments:

Name: mx
Type: (:diagonal-matrix %number)
Description: A matrix

Name: row
Type: <integer>
Description: Row index

Name: column
Type: <integer>
Description: Column index

Result value: The element of the matrix at the given position

Result type: `%number`

Purity of the procedure: pure

Note that elements outside the diagonal are zero.

matrix-set!

Syntax:

```
(matrix-set! mx row column element-value)
```

Type parameters: `%number`

Arguments:

Name: `mx`
Type: `(:matrix %number)`
Description: A matrix

Name: `row`
Type: `<integer>`
Description: Row index

Name: `column`
Type: `<integer>`
Description: Column index

Name: `element-value`
Type: `%number`
Description: The new value at the specified position

No result value.

Purity of the procedure: nonpure

matrix-set!

Syntax:

```
(matrix-set! mx row column element-value)
```

Type parameters: `%number`

Arguments:

Name: `mx`
 Type: `(:diagonal-matrix %number)`
 Description: A matrix

Name: `row`
 Type: `<integer>`
 Description: Row index

Name: `column`
 Type: `<integer>`
 Description: Column index

Name: `element-value`
 Type: `%number`
 Description: The new value at the specified position

No result value.

Purity of the procedure: nonpure

The row and column indices have to be equal.

number-of-columns*Syntax:*

`(number-of-columns mx)`

Type parameters: `%number`

Arguments:

Name: `mx`
 Type: `(:matrix %number)`
 Description: A matrix

Result value: Number of columns in the matrix

Result type: `<integer>`

Purity of the procedure: pure

number-of-columns

Syntax:

```
(number-of-columns mx)
```

Type parameters: %number

Arguments:

```
Name: mx  
Type: (:diagonal-matrix %number)  
Description: A matrix
```

Result value: Length of the diagonal

Result type: <integer>

Purity of the procedure: pure

number-of-rows

Syntax:

```
(number-of-rows mx)
```

Type parameters: %number

Arguments:

```
Name: mx  
Type: (:matrix %number)  
Description: A matrix
```

Result value: Number of rows in the matrix

Result type: <integer>

Purity of the procedure: pure

number-of-rows

Syntax:

```
(number-of-rows mx)
```

Type parameters: %number

Arguments:

Name: mx
Type: (:diagonal-matrix %number)
Description: A matrix

Result value: Length of the diagonal

Result type: <integer>

Purity of the procedure: pure

Chapter 21

Module (standard-library dynamic-list)

21.1 Simple Procedures

d-append

Syntax:

```
(d-append lst-1 ... lst-n)
```

Arguments:

Name: `lst-k`
Type: `<object>`
Description: A list

Result value: A list constructed by concatenating the argument lists

Result type: `<object>`

Purity of the procedure: pure

The lists are concatenated in the order they are given.

d-car

Syntax:

```
(d-car obj)
```

Arguments:

Name: `obj`
Type: `<object>`
Description: An object

Result value: The head of the pair

Result type: `<object>`

Purity of the procedure: pure

If the argument is not a pair an exception is raised.

d-cdr

Syntax:

```
(d-cdr obj)
```

Arguments:

Name: `obj`
Type: `<object>`
Description: An object

Result value: The tail of the pair

Result type: `<object>`

Purity of the procedure: pure

If the argument is not a pair an exception is raised.

d-for-each

Syntax:

```
(d-for-each proc lst-1 ... lst-n)
```

Arguments:

Name: `proc`
Type: `(:procedure (<object>) <none> nonpure)`
Description: A procedure to be applied into the given lists

Name: `lst-k`

Type: <object>
Description: A list

No result value.

Purity of the procedure: nonpure

This procedure is similar to `for-each`, see section 3.5.3. The given procedure is applied to the given lists and the results are discarded.

d-for-each1

Syntax:

```
(d-for-each1 proc lst)
```

Arguments:

Name: `proc`
Type: (:procedure (<object>) <none> nonpure)
Description: A procedure to be applied into the given list

Name: `lst`
Type: <object>
Description: A list

No result value.

Purity of the procedure: nonpure

This procedure applies the given procedure to the given list and discards the results.

d-list

Syntax:

```
(d-list obj-1 ... obj-n)
```

Arguments:

Name: `obj-k`
Type: <object>
Description: An object

Result value: A list constructed from the arguments

Result type: <object>

Purity of the procedure: pure

d-list-ref

Syntax:

```
(d-list-ref lst index)
```

Arguments:

Name: `lst`

Type: <object>

Description: A list

Name: `index`

Type: <integer>

Description: Index to the list

Result value: The object at the specified position in the given list

Result type: <object>

Purity of the procedure: pure

d-map

Syntax:

```
(d-map proc lst-1 ... lst-n)
```

Arguments:

Name: `proc`

Type: (:procedure (<object>) <object> pure)

Description: A procedure to be applied into the given list

Name: `lst-k`

Type: <object>

Description: A list

Result value: A list constructed by applying the procedure to the elements of

the lists

Result type: <object>

Purity of the procedure: pure

This procedure is similar to `map`, see section 3.5.3.

d-map1

Syntax:

```
(d-map1 proc lst)
```

Arguments:

Name: `proc`

Type: (:procedure (<object>) <object> pure)

Description: A procedure to be applied into the given list

Name: `lst`

Type: <object>

Description: A list

Result value: A list constructed by applying the procedure to each element of the list

Result type: <object>

Purity of the procedure: pure

d-map-nonpure

Syntax:

```
(d-map-nonpure proc lst-1 ... lst-n)
```

Arguments:

Name: `proc`

Type: (:procedure (<object>) <object> nonpure)

Description: A procedure to be applied into the given lists

Name: `lst`

Type: <object>

Description: A list

Result value: A list constructed by applying the procedure to the elements of the lists

Result type: <object>

Purity of the procedure: nonpure

This procedure is similar to `map-nonpure`, see section 3.5.3.

d-map-nonpure1

Syntax:

```
(d-map-nonpure1 proc lst)
```

Arguments:

Name: `proc`

Type: `(:procedure (<object>) <object> nonpure)`

Description: A procedure to be applied into the given list

Name: `lst`

Type: <object>

Description: A list

Result value: A list constructed by applying the procedure to each element of the list

Result type: <object>

Purity of the procedure: nonpure

Chapter 22

Module (standard-library singleton)

22.1 Data Types

Data type name: `:singleton`

Type: `<param-logical-type>`

Number of type parameters: 1

Description: A singleton object

A singleton is an object containing a single value.

22.2 Parametrized Procedures

`make-singleton`

Syntax:

```
(make-singleton element)
```

Type parameters: `%type`

Arguments:

Name: `element`

Type: `%type`

Description: An object

Result value: A new singleton object containing the given value

Result type: `(:singleton %type)`

Purity of the procedure: pure

singleton-get-element

Syntax:

```
(singleton-get-element sgt)
```

Type parameters: %type

Arguments:

Name: `sgt`
Type: `(:singleton %type)`
Description: A singleton

Result value: The value contained in the argument object

Result type: %type

Purity of the procedure: pure

singleton-set-element!

Syntax:

```
(singleton-set-element! sgt new-element)
```

Type parameters: %type

Arguments:

Name: `sgt`
Type: `(:singleton %type)`
Description: A singleton

Name: `new-element`
Type: %type
Description: The new element value

No result value.

Purity of the procedure: nonpure

The element of the singleton `sgt` is set to `new-element`.

Chapter 23

Module (standard-library hash-table)

When a hash table is used the hash procedure and the equality predicate used by the association procedure must be compatible with each other, i.e. the hash procedure shall never compute different hash values for objects that are equal by the equality predicate.

When you create object hash tables or string hash tables you have to manually dispatch the value type. For example to create a string hash table with symbols as the value type use code

```
((param-proc-dispatch make-string-hash-table-with-size <symbol>
 100)
```

23.1 Data Types

Data type name: <raw-hash-table>

Type: <class>

Description: The low-level guile hash table class. This class should not be used directly.

Data type name: :hash-proc

Type: parametrized procedure class

Number of type parameters: 1

Description: The type of a hash procedure. The type parameter is the type of the values to be hashed.

Data type name: :assoc-proc

Type: parametrized procedure class

Number of type parameters: 2

Description: The type of an association procedure for hash tables. The first type parameter is the type of the key and the second the type of the values with

which the keys are associated.

Data type name: `:hash-table`

Type: `<param-class>`

Number of type parameters: 2

Description: The parametrized class for hash tables. The first parameter is the type of the keys and the second the type of the values with which the keys are associated.

Data type name: `:object-hash-table`

Type: `<param-class>`

Number of type parameters: 1

Description: The parametrized class for hash tables for which the keys are arbitrary objects. The type parameter is the type of the associated values.

The hash procedure is compatible with the association procedure `object-assoc` with the following:

- symbols
- booleans
- characters
- strings
- user defined nonprimitive classes
- pairs
- vectors (all four kinds of vectors)

The equivalence predicate used by `object-assoc` is equivalent to `equal-objects?` for these classes. Note that if you use this class with string or pair keys the keys are considered equal if they are the same object.

Data type name: `:string-hash-table`

Type: `<param-class>`

Number of type parameters: 1

Description: The parametrized class for hash tables for which the keys are strings. The type parameter is the type of the associated values.

23.2 Simple Procedures

`object-hash`

Syntax:

```
(object-hash obj size)
```

Arguments:

Name: `obj`

Type: `<object>`

Description: The object for which the hash value is computed

Name: `size`

Type: `<integer>`

Description: The size of the hash table for which the hash value is computed.

Result value: Hash value

Result type: `<integer>`

Purity of the procedure: pure

string-hash

Syntax:

```
(string-hash str size)
```

Arguments:

Name: `str`

Type: `<string>`

Description: The string for which the hash value is computed

Name: `size`

Type: `<integer>`

Description: The size of the hash table for which the hash value is computed.

Result value: Hash value

Result type: `<integer>`

Purity of the procedure: pure

23.3 Parametrized Procedures

hash-count-elements

Syntax:

```
(hash-count-elements hashtable)
```

Type parameters: %key, %value

Arguments:

Name: `hashtable`
Type: `(:hash-table %key %value)`
Description: A hash table

Result value: The number of elements in the hash table

Result type: <integer>

Purity of the procedure: pure

hash-exists?

Syntax:

```
(hash-exists? hashtable key)
```

Type parameters: %key, %value

Arguments:

Name: `hashtable`
Type: `(:hash-table %key %value)`
Description: A hash table

Name: `key`
Type: %key
Description: Key to be searched

Result value: Returns `#t` iff the given key is found from the hash table

Result type: <boolean>

Purity of the procedure: pure

hash-ref

Syntax:

```
(hash-ref hashtable key default)
```

Type parameters: %key, %value, %default

Arguments:

Name: `hashtable`
 Type: `(:hash-table %key %value)`
 Description: A hash table

Name: `key`
 Type: `%key`
 Description: Key to be searched

Name: `default`
 Type: `%default`
 Description: The default value

Result value: The value associated with the given key in the hash table. Returns `default` if the key is not found.

Result type: `(:union %value %default)`

Purity of the procedure: pure

hash-remove!

Syntax:

```
(hash-remove! hashtable key)
```

Type parameters: %key, %value

Arguments:

Name: `hashtable`
 Type: `(:hash-table %key %value)`
 Description: A hash table

Name: `key`
 Type: `%key`
 Description: Key to be defined

No result value.

Purity of the procedure: nonpure

This procedure removes the given key from the hash table. If the key is not found the procedure does nothing.

hash-set!

Syntax:

```
(hash-set! hashtable key value)
```

Type parameters: %key, %value

Arguments:

Name: **hashtable**
Type: (:hash-table %key %value)
Description: A hash table

Name: **key**
Type: %key
Description: Key to be defined

Name: **value**
Type: %value
Description: Value to be associated

No result value.

Purity of the procedure: nonpure

This procedure associates the given key with the given value in the hash table.

make-hash-table

Syntax:

```
(make-hash-table proc-hash proc-assoc)
```

Type parameters: %key, %value

Arguments:

Name: **proc-hash**
Type: (:hash-proc %key)
Description: A procedure to compute hash values

Name: `proc-assoc`
Type: `(:assoc-proc %key %value)`
Description: A procedure to associate keys and values

Result value: A hash table
Result type: `(:hash-table %key %value)`

Purity of the procedure: pure

`make-hash-table-with-size`

Syntax:

```
(make-hash-table-with-size proc-hash proc-assoc size)
```

Type parameters: `%key`, `%value`

Arguments:

Name: `proc-hash`
Type: `(:hash-proc %key)`
Description: A procedure to compute hash values

Name: `proc-assoc`
Type: `(:assoc-proc %key %value)`
Description: A procedure to associate keys and values

Name: `size`
Type: `<integer>`
Description: Size of the hash table

Result value: A hash table with given size
Result type: `(:hash-table %key %value)`

Purity of the procedure: pure

`make-object-hash-table`

Syntax:

```
(make-object-hash-table)
```

Type parameters: %value

No arguments.

Result value: An object hash table

Result type: (:object-hash-table %value)

Purity of the procedure: pure

make-object-hash-table-with-size

Syntax:

```
(make-object-hash-table-with-size size)
```

Type parameters: %value

Arguments:

Name: `size`

Type: <integer>

Description: Size of the hash table

Result value: An object hash table with given size

Result type: (:object-hash-table %value)

Purity of the procedure: pure

make-string-hash-table

Syntax:

```
(make-string-hash-table)
```

Type parameters: %value

No arguments.

Result value: A string hash table

Result type: (:string-hash-table %value)

Purity of the procedure: pure

make-string-hash-table-with-size

Syntax:

```
(make-string-hash-table-with-size size)
```

Type parameters: %value

Arguments:

Name: `size`
Type: `<integer>`
Description: Size of the hash table

Result value: A string hash table with given size

Result type: `(:string-hash-table %value)`

Purity of the procedure: pure

object-assoc

Syntax:

```
(object-assoc object a-list)
```

Type parameters: %value

Arguments:

Name: `object`
Type: `<object>`
Description: The object to be searched

Name: `a-list`
Type: `(:a-list <object> %value)`
Description: The association list from which the object is searched

Result value: The association or `null` if none is found.

Result type: `(:maybe (:pair <object> %value))`

Purity of the procedure: pure

string-assoc

Syntax:

```
(string-assoc str a-list)
```

Type parameters: %value

Arguments:

Name: `str`

Type: `<string>`

Description: The string to be searched

Name: `a-list`

Type: `(:a-list <object> %value)`

Description: The association list from which the string is searched

Result value: The association or null if none is found.

Result type: `(:maybe (:pair <string> %value))`

Purity of the procedure: pure

Chapter 24

Module (standard-library statprof)

This is a wrapper module for guile profiler `statprof`. Note that all features of `statprof` are not supported. A simple use of `statprof` would look like this:

```
(statprof-reset 0 50000 #f)
(statprof-start)
(do-something)
(statprof-stop)
(statprof-display)
```

See guile 2.0 documentation for further information.

24.1 Simple Procedures

`statprof-start`

Syntax:

```
(statprof-start)
```

No arguments.

No result value.

Purity of the procedure: nonpure

Start profiling.

statprof-stop

Syntax:

```
(statprof-stop)
```

No arguments.

No result value.

Purity of the procedure: nonpure

Stop profiling.

statprof-reset

Syntax:

```
(statprof-reset sample-seconds sample-microseconds count-calls?)
```

Arguments:

Name: `sample-seconds`

Type: `<integer>`

Description: Seconds for the sampler interval

Name: `sample-microseconds`

Type: `<integer>`

Description: Microseconds for the sampler interval

Name: `count-calls?`

Type: `<boolean>`

Description: `#t` to count procedure calls

No result value.

Purity of the procedure: nonpure

Reset the profiler.

statprof-display

Syntax:

`(statprof-display)`

No arguments.

No result value.

Purity of the procedure: nonpure

Display a summary of the statistics collected.

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